本田賞15周年記念エコ・テクノロジー・シンポジウム

「21世紀のパラダイム・シフトを考える」
講演録

財団法人 本田財団

The Eco-Technology Symposium

"Paradigm Shift in the 21st Century"

to

Commemorate The Honda Prize 15th Anniversary

Date : Friday, Novemder 18, 1994
Place : The United Nations University Headquarters
: The International Conference Hall(3F)

1st part Keynote Speaches

"Eco-Technology and Sustainable Development"

Prof. Umberto Colombo

5th recipient of the Honda Prize
(Chairman of Science Board, ENI-Enrico Mattei Foundation)

1927 Born in Livorno, Italy
1965-72 Professor of Industrial Chemistry, University of Genoa
1979-93 Chairman of the Italian National Commission for Nuclear and Alternative Energy Sources (ENEA)
1993 Minister for Universities and Scientific and Technological Research in the Government of Italy
1994- Chairman of Scientific Board, ENI-Enrico Mattei Foundation

"Harmonization of Science/Technology and Human Society in the 21st Century"

President Jun-ichi Nishizawa

7th recipient of the Honda Prize
(Tohoku University)

1926 Born in Miyagi Prefecture, Japan
1948 B.Sc., Tohoku University, Faculty of Engineering
1962-90 Professor of Tohoku University
1981 Project Director, Nishizawa Perfect Crystal Project, Science and Technology Agency
1990- Emeritus Professor of Tohoku University
President of Tohoku University

2nd part Panel Discussion

●Panelists

Prof. Umberto Colombo
President Jun-ichi Nishizawa

Prof. Benoit B. Mandelbrot
15th recipient of the Honda Prize
(Yale University, Fractal Geometry)

1924 Born in Warsaw, Poland
1947 Ingénieur de l'Ecole Polytechnique, Paris, France
1952 D.Sc., in Mathematics, University of Paris
1958-93 Research staff member, IBM T.J. Watson Research Center
1974 IBM Fellow
1987- Abraham Robinson Professor of Mathematical Sciences, Yale University
Awarded the Barnard Medal for meritorious Service to Science, the Humboldt prize, the Harvey Prize for Science and Technology and the Wolf Foundation Prize for Physics.

Prof. Koki Hrikoshi
14th recipient of the Honda Prize
(Toyo University, Microbiology)

1932 Born in Saitama Prefecture, Japan
1956 B.S. University of Tokyo, Faculty of Agriculture
1974-91 Professor of the Dept. of Applied Microbiology at Riken Institute
1988-93 Professor, Tokyo Institute of Technology
1990- Director, the DEEP STAR project at the Marine Science Research Center
1993- Professor, Toyo University
Awarded a prize from the Agricultural Chemical Society of Japan and Gold Medal from the International Instiute of Biotechnology at the Royal Society, London.

Prof. Takashi Hoamada
(The University of the Air, Earth Environment Transition History)

1993 Born in Miyazaki Prefecture, Japan
1960 Ph.D., University of Tokyo
1980 Professor, University of Tokyo
1993- Professor, University of the Air
Professor Hamada is also a committee member of the Science and Technology Policy Research Institute of the Japanese Government, and the Japan Science Association and the National History Scientific Research Institute, as well as an advisory member of NHK special program "Life's Journey for 4 billion Years."

●Coordinator

Prof. Reikichi Shirane
(Tama Institute of Manage-ment and information Sciences, information Engineering)

1927 Born in Akita Prefecture, Japan
1948 B.Sc., Tohoku University, Faculty of Engineering
1948 Engineering Department of the Ministry of Posts and Telecommunications
1975 President of NTT Telecommunication Science Foundation
1990- Professor, Tama Institute of Management and Information Sciences
Professor Shirane is also the director of the Japan Society of Information and Communication Research and the Honda Foundation. Commended by the Minister of Posts and Telecommunications and awarded the Telecommunication Association award, among others.

THE Eco-Technology Symposium "Paradigm Shift in the 21st Century"

First Part-Keynote Speeches Eco-technology and Sustainable Development

Professor Umberto Colombo
Chairman of Science Board, ENI-Enrico Mattei, Foundation

Rector Magnificos of the United Nations University, Mr. Chairman, Ladies and Gentlemen:

First of all, I should like to express my heartfelt thanks to the Honda Foundation for inviting me to participate in today's symposium, and most important to attend yesterday's Ceremony of Award of the 15th Honda Prize to Professor Benoit Mandelbrot.

The Award this year to such a distinguished international scientist makes all of us members of the family of laureates of the Honda Prize feel very proud indeed. I am also grateful to the Honda Foundation because this is for me the first opportunity to be in the headquarters of the United Nations University of whose Council I have served for 6 years until about 3 years ago after completion of this magnificent building and masterpiece of modern Japanese architecture.

The subject which was assigned to me is "Eco-technology and Sustainable Development."

Growing preoccupation over the degradation of the environment, both at the local and at the global scale, has drawn attention towards Eco-technology, that is , technology which is in harmony with ecology and therefore allows us to contribute long term to the sustainability of development. The issue at stake for us is to continue and indeed improve economic standards and the quality of life without prejudice for future generations. Emphasis in Eco-technology is on preventing waste and harm to the environment, rather than in repairing the damage once it has been made.

Sustainability therefore implies saving non-renewable resources, such as fossil fuels and raw materials, and limiting the quantity of wastes which are produced and cannot be recycled, in particular those which are toxic or otherwise harmful. The environment is itself a finite resource, which is only in part renewable: it has a limited carrying capacity, in the sense that it can absorb a limited amount of pollution and heal the damage suffered, but once a certain threshold is surpassed, it suffers damage which is often irreversible. The same is true for the preservation of ecosystems and biodiversity, and for the stability of the global climate against a man-enhanced greenhouse effect.

The trend towards Eco-technology is to a large extent inherent in the progress of advanced industrialised societies away from quantity towards quality. Eco-technology uses less materials, and in particular less scarce materials. Many examples of the trend toward Eco-technology can be given. Miniaturisation, for instance, not only concerns microelectronics (a

very well known case); with the advent of nanotechnologies, it is increasingly penetrating the field of machinery as well as that of bioengineering. The reduction in weight due to new materials and improved design is sometimes dramatic: the weight-to-power ratio for locomotives has decreased by a factor 80 in the last 180 years. A similar (although less spectacular) reduction may be experienced in the future by automobiles, with the advent of ultra-light "supercars", based on advanced composite materials. A much greater and faster weight and size reduction has of course occurred with computers.

In some cases, entirely new technical solutions allow us to avoid altogether the use of potentially scarce materials: optical fibres replace copper cables in telecommunications, and the even more immaterial use of electromagnetic waves is also an option.

New technologies also use less energy: directly, because they reduce unnecessary losses, improve "housekeeping" procedures, recover waste heat, or employ entirely novel processes; and indirectly because they employ less materials reducing their overall energy content.

It is now possible to substitute technology for material inputs, quality for quantity. This trend, together with shifts in demand away from material-intensive products toward services and immaterial goods, is responsible for the process of "dematerialisation" which is taking place in advanced industrial economies, evolving towards a post-industrial society dominated by information and communications.

Economics has been driving dematerialisation. This is not direct cause and effect. In fact the price (in real terms) of most raw materials has been constantly decreasing, rather than increasing as one might expect from their finite nature and their impending scarcity. Progress in process technologies has prompted more efficient use of materials. But the desire to expand the volume of sales has led enterprises, especially in durable consumer goods, to introduce in their products elements of planned obsolescence, which is clearly in contrast with the concept of sustainability. Actions are needed to correct this short-sighted approach be it through norms, or by internalising in the price of the products the external costs that are borne by society as a consequence of their production, use and disposal. The environmental impact that the flood of batteries that the consumer electronics industry has unleashed on the world is a case in point. Public awareness should be stimulated to influence demand toward products which are more friendly to the environment and/or have been produced by ecologically-sound technologies.

It is through a combination of these actions that new steps towards Eco-technology are being taken. These include, among others, life cycle analysis of products, and increased reliance on the systematic recycling of materials, parts and whole objects.

If in advanced industrialised countries the situation has encouraging features (even if it is far from being completely satisfactory in terms of sustainability), the case of developing countries is much worse. First, their population is rapidly expanding. Second, their per capita

GDP is also growing in most cases, or it should be. Third, and perhaps more important, the efficiency of the technologies employed in developing countries is lower than that of the industrial countries, as indicated by the high intensity of materials and energy, and waste generation per unit of GDP.

Let us concentrate on this: why this higher energy and materials intensity? This is in part "physiological". Any country going through the process of industrialisation has to build up heavy infrastructures (factories, roads and railroads, bridges, buildings...) with associated huge consumption of materials and energy. This, in turn, is likely to place a heavy burden on the environment. In a later stage, the country has to satisfy a demand for basic durable goods which are also material-intensive. Only when most of the heavy infrastructures are in place and the demand for durable goods begins to be saturated, the process of dematerialisation induces a decrese in the material intensity of GDP.

But in today's developing countries, the current indices of intensity are higher than those ever attained even in countries of recent industrialisation, such as Italy or Japan. This means two things: one is that the most modern, efficient technologies which are available in industrialised countries are not easily accessible to developing countries because they are either too expensive or protected by patents and restricted know-how. The second is that the poorest countries and also those with a high rate of economic growth, often have other priorities than long-term sustainability.

Environmental awareness is, however, rising. For instance, China is giving serious consideration to the objectives and recommendations of Agenda 21 and is now trying to find ways to alleviate the consequences of its heavy dependence on coal for energy production (not only for electricity and industry, but also for domestic heating and even cooking).

The lack of advanced, up-to-date, efficient technologies in developing countries is often due to the fact that aid-to-development programmes from most, if not all, advanced countries have so far aimed at supporting their own lame-duck industries, rather than responding to the real needs of developing countries. It therefore often happens that technologies which are obsolete or have performed poorly end up being transferred to the Third World.

What is really needed is rather the opposite. There is no reason why countries that are developing today should follow the development pattern of the previously industrialised countries. In fact, Japan and Italy, whose industrial development took place much later than in countries such as the UK and the US, have made use of more efficient up-to-date technologies. The same could take place now in developing countries, where the choice of suitable Eco-technology would be enormously beneficial. This concept is referred to as "leapfrogging" and is now receiving wide attention as a truly modern instrument of development.

The introduction of advanced technologies into developing countries will not happen automatically, however. A new technology must be adapted to the environment into which it

is transplanted in more than one way: it must respond to an effective need, it must be basically understood by the people who use it, it must be adapted to econmic and social conditions and not be in contrast with the cultural background. Local traditions must be taken into account. Furthermore, some basic infrastructure may be required and adequate maintenance has to be assured.

All these may appear as rather stringent conditions which are difficult to be met by an innovative technomology in a developing world context. However, this is just as true for more traditional technologies, although it is not often taken into due account. In comparison, advanced technologies are often more user-friendly than traditional ones and can be more easily assimilated. A few examples may clarify this point. New generations in developing countries have accepted and assimilated the use of computers nearly as fast as in industrialised countries (even if their diffusion in the market is much more limited). No one would think of installing first- or second-generation computers in developing countries, not only because they would be much more expensive, but also becasuse they are not so easy to maintain. A modern, user-friendly computer is able to self-diagnose any malfunctioning and immediately indentifies the component to be replaced. This makes maintenance very simple. It is not necessary for the user to understand fully what is in a card or in a chip, or how it works. Another example is the use of advanced gas turbines derived from the aeronautics industry to produce electricity with high efficiency. Although the technology needed to design and fabricate such a turbine is much more advanced than that employed for a conventional steam turbine, the gas turbine itself is familiar to people who run and maintain aeroplanes using the same component. In the event of major problems, the turbine in the generating plant can be disconnected, lifted out and replaced in a matter of days, if not hours. The repair of a steam turbine requires much more work to be done on site, greatly increasing down time. Incidentally, the coupling of a biomass gassifier with such a gas turbine is one scheme for power generation receiving much attention today, indeed a good example of Eco-technology.

The absence of technological infrastructure in place can, in some cases, be an element favouring leap-frogging. In a sparsely inhabited region where a hard-wired telephone network does not exist, it may make more sense to start directly with cellular phones which require far fewer fixed installations. The absence of an electric grid is a stimulus to consider distributed forms of electricity generation (whenever possible, from renewable sources of energy): a trend which, for very different reasons, is now receiving increasing attention in advanced countries, even where an electric grid is alredy in place.

Opportunities may slso be exploited when dealing with the expansion of basic industry in Third World countries. One example is the production of steel: new methods which are more efficient, more cost-effective, flexible and environmentally attractive are now available. These methods find less application in industrialised countries because of the current stagnation in demand for steel, which is not encouraging expansion of production. As long as present plants are operating below capacity, no new plants are going to be built. In contrast, in countries like China and the whole of South and South-East Asia demand for steel is growing

rapidly, and new plants are being built every year. There should be no obstacle in principle to adopt new processes and technologies which are more effective, and more responsive to the environmental imperative underpinning Eco-technology.

It should be noted that Eco-technology does not necessarily originate in advanced countries. Examples can be found of new environment-friendly technologies developed in Third World countries, which could diffuse to other developing countries. One often quoted example is reduction of iron ore using charcoal which is common in Brazil, and which - in addition to using a renewable resource in place of coal-yields iron with superior magnetic properties, due to the absence of contaminants present in coal. Another example, again relative to Brazil, is their ProAlcool programme for the production of ethanol from sugar cane to replace petroleum-derivied fuels. Although this process is not competitive today from a purely economic point of view, there are indications that, with the injection of some advanced technologies available in industrialised countries (in particular, energy production from waste bagasse), it could become so even at today's low oil prices.

Another region of the world in which great advantages could be obtained by adopting modern Eco-technology is Central and Eastern Europe including the former Soviet Union. Also in this region, the energy and materials intensity of GDP is very high, actually much higher than in the average developing country. Moreover, the environmental situation is heavily compromised. The absence of market mechanisms and previous isolation from the advanced industrial countries in the OECD are at the origin of this situation. The artificial accounting system used during the period of central planning actually discouraged efficiency. The objectives of five-year plans for a given industry were generally assigned in terms of weight or numbers, rather than value. It was therefore much more convenient to produce objects that were as heavy or as many as possible, independently of their true value or their environmental impact, or of demand for them.

In these countries, however, the competence of their scientists and engineers is very high, even if many of the best of them (especially in the former USSR) were employed by the military sector. The introduction of market mechanisms and of more stringent environmental regulations, together with the utilisation for civilian purposes of forces which were previously frozen in the military circuit, should greatly favour the development and application of Eco-technology. Advanced industrial democracies can help and speed up this process, not so much by providing scientific and technical input, as by supplying practical know-how, direct experience and organisation capabilities.

In conclusion, the development and diffusion of Eco-technology should be a first priority objective in order to protect our global environment and climate thus shaping a sustainable future. Although this objective concerns all the countries in the world, industrialised countries have the major responsibility. This is both because they are still responsible for the consumption of the larger share of non-renewable resources and they make an unnecessarily great contribution to environmental damage and climate instability. Moreover they have to

hand the advanced technological know-how and the economic resources needed to lead a global transition towards truly sustainable development. A great effort on their part to help developing countries in this direction would be not so much an expression of altruism as an effort to ensure a better future for the whole of Mankind. It is not possible to pursue sustainability in isolation. One part of the Planet cannot adopt environmentally-friendly policies and hope to be immune from the impact of patterns of economic behaviour elsewhere. The global nature of negative environmental impacts are now before our eyes. Eco-technology is no longer an option, it is an obbligation. The sooner advanced nations embrace its precepts, and promote them worldwide, the better for all of us.

Harmonization of Science／Technology and Human Society in the 21st Century

President Jun-ichi Nishizawa

It is often said that in the 20th century is a century of science and technology. However, in retrospect I wonder whether the overall direction of the development of science and technology is always right. I rather doubt it.

At the time when the Malthusian's preparation theory was advocated, when the globe was covered by the roaming number of population, Engels (according to my memories) had a desire of the development of technologies so that the science and technology could overcome all the problems that the mankind may face even when the population exploded. That was Engels expressed his expectation toward the science and technology. At that time, his view might have been right, however, there were some other side effects at the develoment of science and technology by polluting and destroying the environment and it is very sad fact that there are so many pessimists about the future of the science and technology.

In the case of Japan, without the natural resources at all, even 50% of food that is consumed by the Japanese are imported. Therefore, in return, Japan has no other resort but to use science and tecnology and exporting its products. Because of its over-dependence in science and technology and despite the fact that Japan had somewhat a mispercepion about the science and technology that was quite unfortunate.

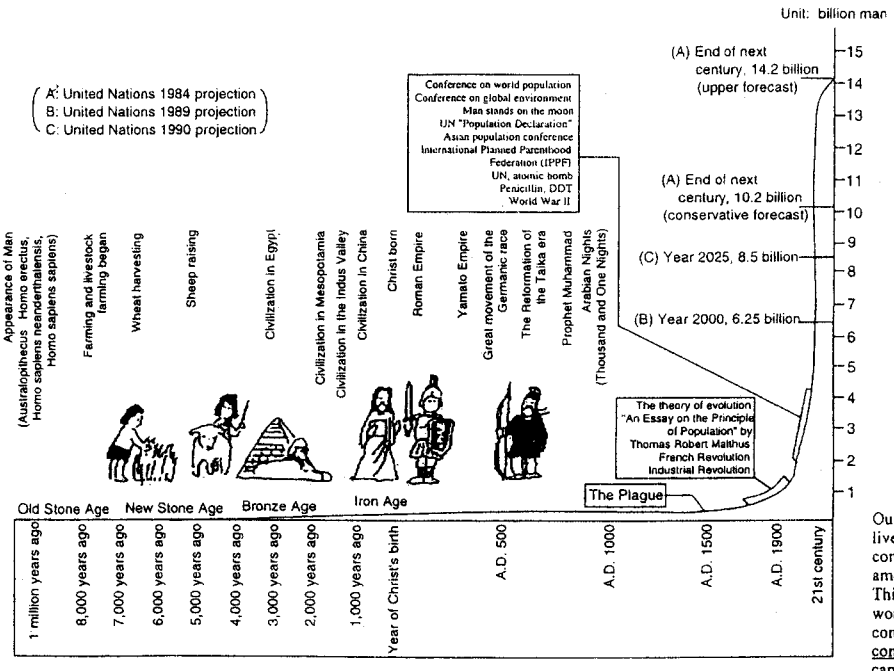
In fact, 20th century was the century of science and technology but it is true at the same time that the mankind committed the serious mistakes. Toward early 20th century, it was often said that around 1700 steam engine was invented followed by the invention of electricity which was distributed to all the households by connecting the cables and now if you just turn on the switch, you can receive the electric energy readily available.

Then came the car, using the engine combusting gasoline and then Henry Ford of the United States developed the inexpensive car. So the steam engine invention, and electricity and its technology and the diffusion of a number of cars used were the 3 epoch-making events in the early centuries in the recent history.

We tend to focus on the steam engine, but rather I would like to emphasize also the significance of the electricity and the cars which provided mankind with the convenience and probably the value of electricity and cars may be even more significant. If I am to digress, the 3 major successes were in fact in Scotland, in the United Kingdom or the country like the United States which was yet to enter into the member of advanced countries.

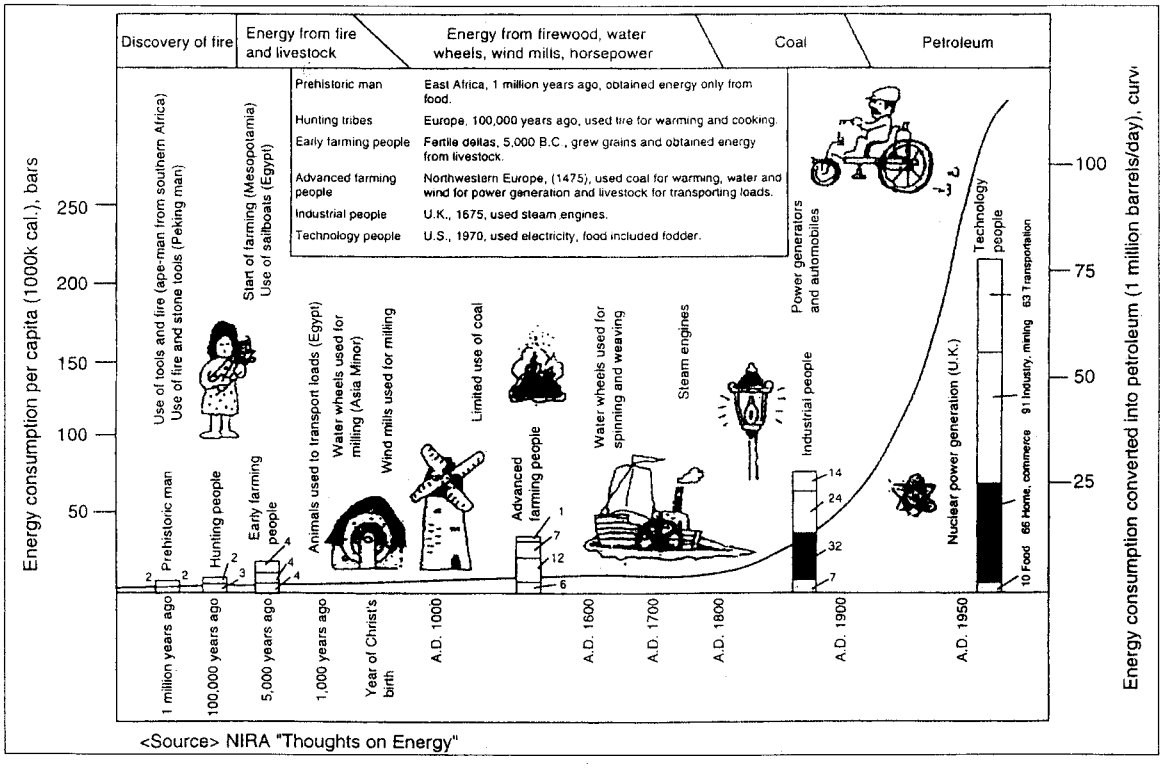
In other words, the invention or epoch-making development are often made not only the city but rather in the countryside, we should keep that in our mind. In other words, wherever inconvenience exists, we feel the need for innovation. That is why such epoch-making invention was made in the under-developed countries.

Since around 1900, electricity, car and steam engine were widely spread so that the per capita cousumption of energy has increased dramatically. For instance, the per capita



Our convenient and comfortable lives today are supported by consumption of energy of an amount inconceivable in olden days. This tremendous expansion of the world's energy consumption has come about through by the combined effects of greater per capita consumption and rapid population growth.

<Source> Minoru Muramatsu, "Thoughts on Population," 1990 UN publication, "White Paper on World Population," etc.



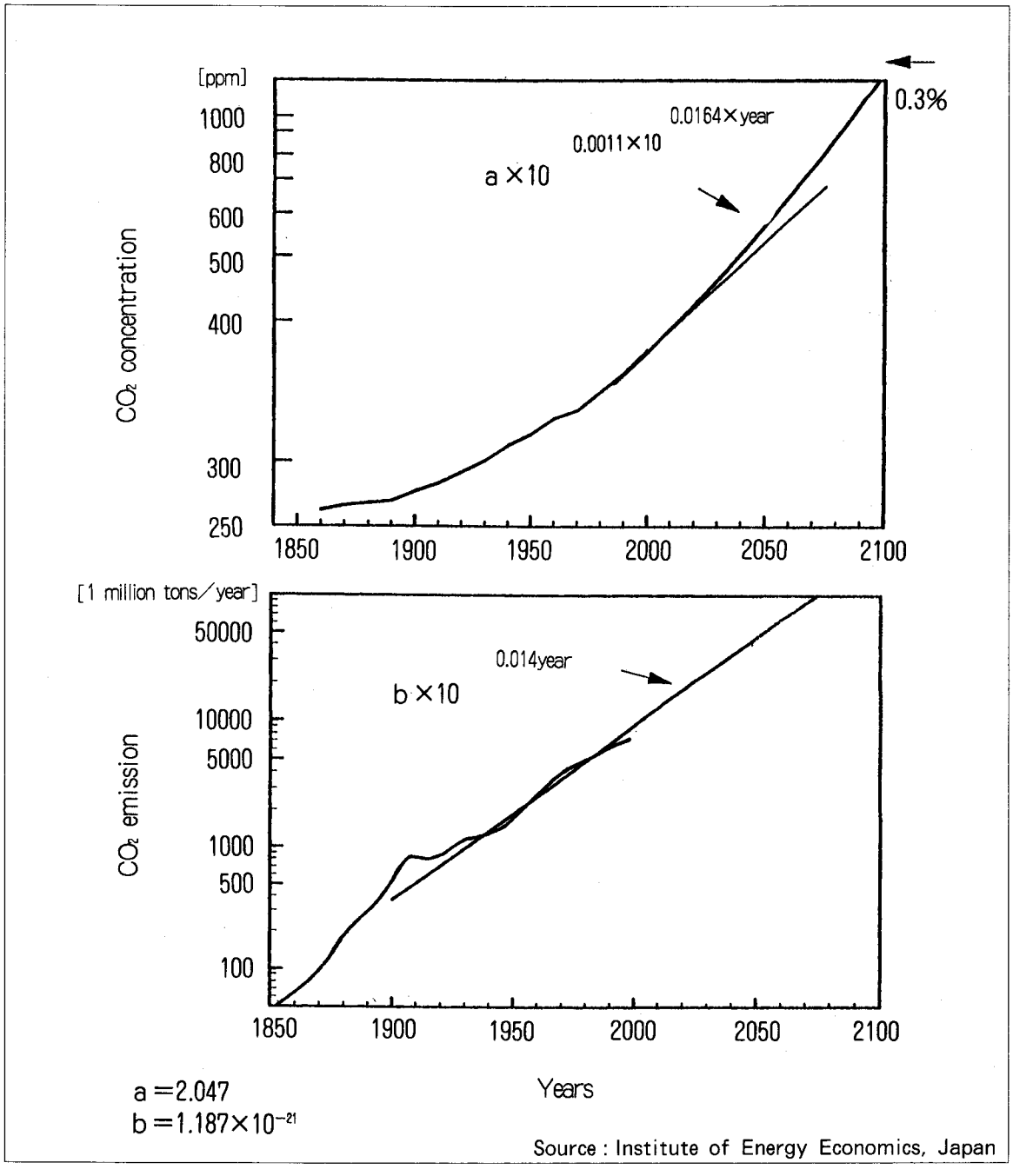
<Source> NIRA "Thoughts on Energy"

consumption of energy was increased by 100 fold in 20th century, especially since around 1900, the energy cousumption started to increase very sharply. As you can see, there is a sharp rise and because of this, we succeeded in reducing the mortality rate drastically.

Now, if you compare this diagram with the previous one, this is 1900 and it is about the time that increase started, that is infantry mortality rate started to decline since around 1900. And during 20th century the world population was increased by 2 fold.

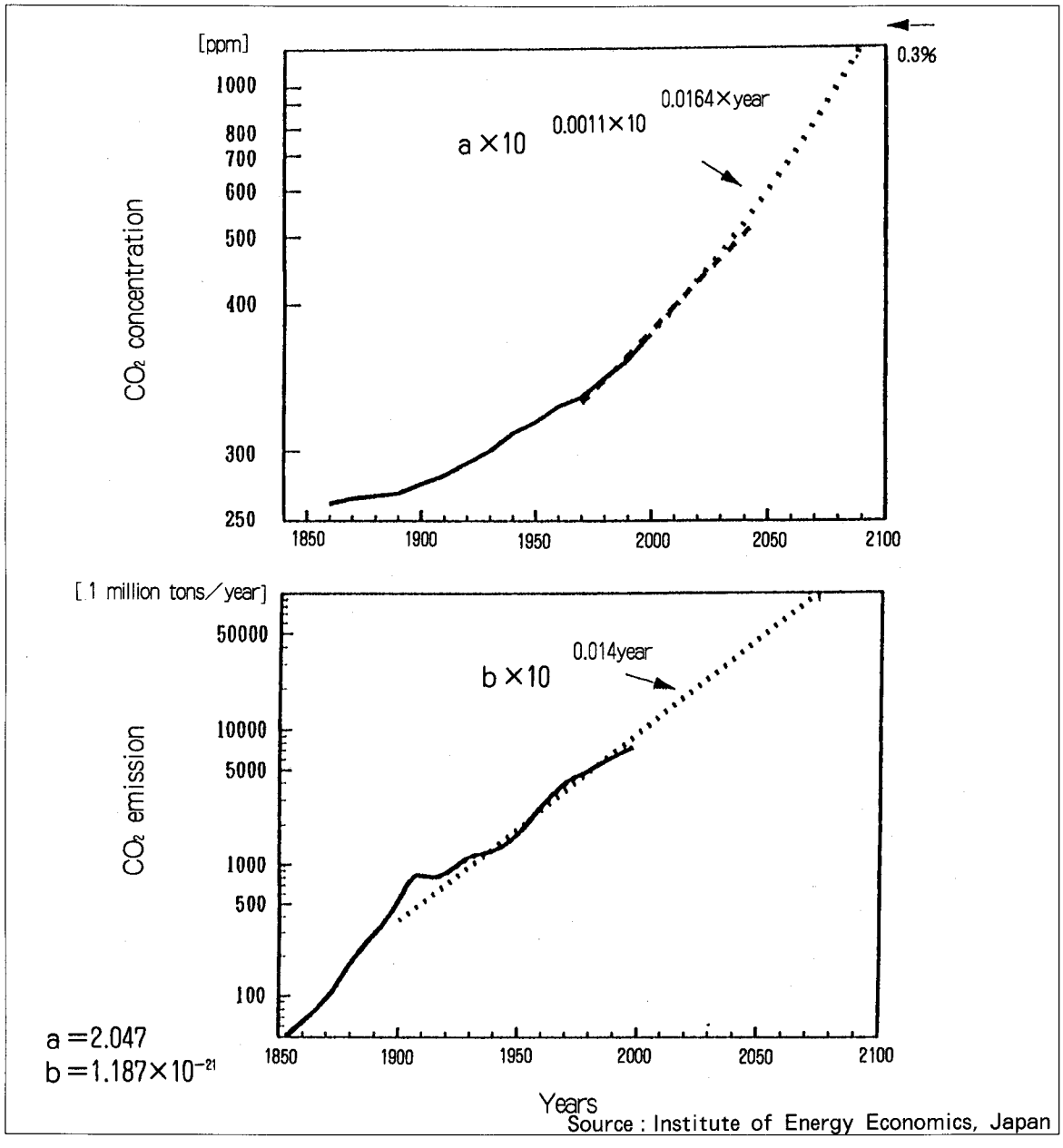
According to some estimation, it seems that it is less than 2 fold increase. That means the population increase is 10 fold whereas the energy consumption was increased by 100, that means the per capita energy consumption was increased by 1000. Therefore, the energy that was continuously sent by the sun for the billions of years were accumulated in the plants and they became the fossil, turning to the fossil fuel accumulated. In other words, this is a blessing of the sun and it seems that the consumption of energy by mankind in the 20th century is so excessive that probably we may use up all the energy that was accumulated thanks to the blessings of the sun.

That is why we finally realized as scientists that sometimes we were too careless and reckless in consuming energy so dramatically. Such dramatic increase of use of coal and oil resulted in the unusually climatic changes in the world. In the diagram in the bottom, the solid line represents the coal and oil consumption and this is a logarithmic scale like the ordinary graph. So when this is linear, it means the increase was exponential, that is, the per annum increase was around 1.4%. This is rather a rough approximation but it is safe to state that the per annum growth rate was about 1.4%.



And now that ten billion tons of carbon dioxide are emitted. Part of them by converted into oxygen by plants, but the rest will rise in the sky and finally accumulate in the atmosphere. If the amount of carbon dioxide emitted is equal to those converted to oxygen by plants, then this line should be flat.

However, as you can see here, the emission exceeds the conversion by plants. If this line is linear then according to some simple approximation, the curve on the top should be linear as well. However, it is clear that it continues to rise very sharply instead of linear increase. Around here is a rather gradual increase but eventually the increase steps up to a very sharp one. At present, the carbon dioxide concentration is said to be around 0.34%. According to



mathematical analysis, the dotted line is what we get based upon this approximation. This is exponential function and as a result, this extension, if it is true, then we would project that in the future, by the year 2080, the concentration of carbon dioxide may be increased by ten times and probably before 2150 the concentration of carbon dioxide reaches at 3.4%, another 10 fold increase.

I applied nothing unusual as the mathematical operation but once the concentration reaches at 3%, the mankind will be suffocated. In other words, if they do nothing scenario is applied, then by mid-21st or 22nd century, the mankind will be suffocated. Of course, there are some people who attempt to counter-argue this theory, but so far such counter-argument is more or less unfounded. If I put it differently then the earth is going back to the state of genesis, that is, even before plants were born.

That is, plants were accumulated in the form of fossil fuel but if they are burnt that means that we are going back to the age before the birth of the plants. Then, before the birth of plants, the globe was covered by the heavily dense carbon dioxide. That is why I mentioned that the earth is going back to the state of the early phase of the genesis.

Therefore, it is certain more or less that the globe is going back to the early age of the genesis. The single difference would be the declining temperature inside the earth instead of rising or high temperature in the genesis. And based upon what I have mentioned I often claim that maybe we are facing the crisis at the end of the century. According to some newspaper, once upon a time they often claimed that the consumption was a virtue. But they went to the extreme state in that waste is a virtue, that is if you dispose of or consume products and goods excessively, then that can help boost up the economy. Of course, that was wrong.

We in the East tend to see Gods, the divine presence in everything. For instance, in Japan we worship mountains, because we believe that there are Gods residing inside the mountains. And in the East we claim that there are 808 Gods, in other words, the God resides in every matter, in everything. That is why in the past we used to try to eliminate waste which was rather different from the Western philosophy.

So, in the past, we didn't dare to waste. It may be wise to review our value system and go back to the original philosophy of the East. I had a chance to visit the tea ceremony master. That was in winter. He pumped up the water from the well on January 1 and made the first tea. That is because they enjoy the cold temperature at the same time as making the tea. In other words, traditionally the Japanese did not think it wise to heat up or warm up the room if it was cold.

In other words, the philosophical satisfaction of the East was somewhat different from what we practice. For a long time, the Japanese as well as people of the East tended to forget our traditional philosophy and we turned to worship the consumption and the waste. We should reflect upon ourselves but now that we are seeing the explosive increase of population, we have to feed them and have to seek the way to co-exist with them. It is not easy at all.

If I go back to this chart again, we need to correct the direction of this curve that is to flatten, that is to drop this. If I put it simply, we need to drastically reduce the consumption of the coal and oil. That is why we need to seek for alternative energy sources. The major cause of the carbon dioxide emission is a car. If those cars are converted to electric cars, in fact that was advocated and committed too by the car industry of the United States at present, and they are now working the project to make the electric cars corresponding to 3% of older cars produced and probably the Japanese car industry should emulate what our counterpart is doing across the ocean.

But what if the electricity that drives the car is supplied from the power station, which burns the fossil fuel. Then there is no major difference at all on the balance sheet. We need to seek for other sources for making electricity. Look around the world. We will find out many rivers that are under-utilized. What if we can make best use of the hydropower?

I did some simple calculation. According to my estimate if one percent of the water in the rivers can be utilized for power generation, then in fact that electricity can supply the power needed for all the population in the world. So if we succeed in the optimum utilization of the hydropower, then we can provide power to all the population. The heaven dries up the steam

and then when the steam coagulates, it eventually turns into rain drops and when the rain drops reach the river as it flows into the river, it can be converted into the electricity. In fact, only 1% of all the water in the rivers is converted that is sufficient.

I was a lazy student when I was at the university although I was majored in the electronic engineering. However, later years I had a chance to give a presentation right ater the OPEC meeting and I consulted with my Dutch counterpart and they confirmed that my calculation was in fact correct.

Therefore, as I have just said, we should encourage and promote the development of the hydropower and in fact we can resolve the problem at once. Then why we fail to do so? That is because of the power distribution technology ever since Edison, the very innovated technology was brought forward in distributing the power. However, currently they are now distributed in AC.

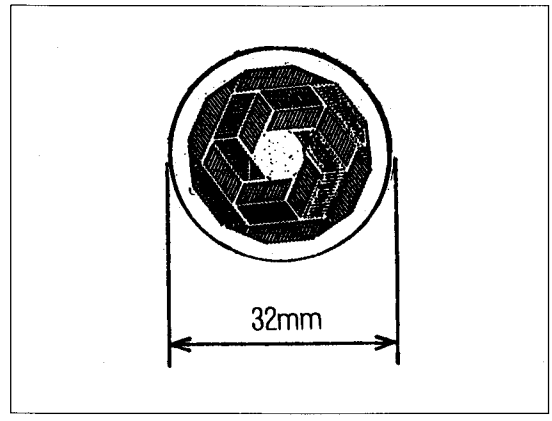
According to the power company utilities, they can reach only 30 kilometers or so with AC (alternate current). But in fact, you have to go beyond that. So I asked them whether that number was wrong but they said they could almost reach 30 kilometers and efficiency will be compromised if they tried to go beyond the 30 kilometer distance. And as a proof, in Japan there is Tsugaru Strait, which is 30 kilometers between Hokkaido and Tohoku. In order to distribute the electricity, the underwater cable was constructed which was hard to modify once it is constructed since it is under the sea.

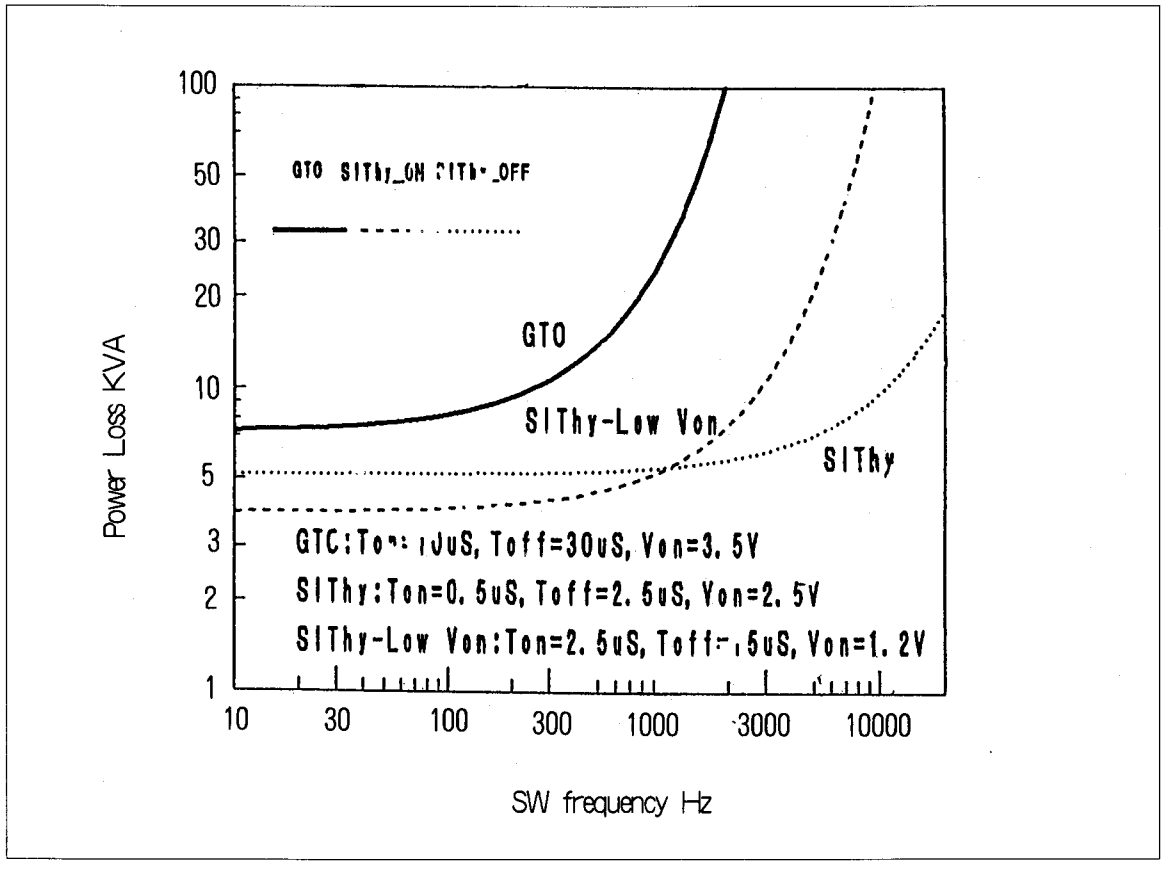
Therefore, it is converted to direct current in order to reach the other side of the Strait. I don't know the current situation because now there is Tsugaru Channel. But I have been through the construction of the Tsugaru Channel, they used to convert alternate current into direct current and with a significant loss they tried to distribute power to the other side of the Strait.

If the hydropower station is constructed at 30 kilometer distance from the city side factory, it was rather difficult to distribute power. But what if they are distributed in the from of DC? I asked an expert how far they could reach with DC and they said it is 10,000 kilometers, which is one quarter of the circumference of the globe. That means if Tokyo is the center of a circle, then in fact you can effectively cover one-half of the globe. So, if you want to have the distribution of the power, you can receive it from the other side of the earth.

In distribution of the electricity, Edison developed the DC distribution but his company eventually bankrupted, because the transformer was not applicable for DC, because the voltage transformation was essential for power distribution. That is why AC power transformation succeeded which was developed by Westinghouse, despite the major defects and Edison company failed.

But at our laboratory, we succeeded in developing a very unique type of device. This is how it looks from the top. This is a kind of a switching device. The device is for amplification but this is for switching, in other words, just like a knife switch, its mechanism is only to turn on or turn off the electricity. Conventionally, no device was available that was capable of turning off the electricity. G. E. of the United States succeeded in developing GTO device.





Our development was somewhat unexpected, that is, our device is capable of turning on and off the electricity with unexpectedly high efficiency. I would like to show you some data collected based upon this switching device that we developed.

This solid line shows GTO gate turn off by general electricity that gauge turn off device at 300 Hz. that is 300 cycle and you can see the loss increases at 300 cycles.

Ours is S. I. thyristor. You will see two examples of ours, one is designed to work on low frequency, 1,000 cycle, that is the cycles which are audible to human ears. And loss starts at 3,000 cycles. You can hear this, this is audible.

Within the range of frequency which is audible to human beings, you can see in this line. As compared to GTO, the loss is nearly one-half of GTO and up to the high frequency, the loss level is very low. This is a device which is working on high frequency and you do not see much loss and then you can see the start of loss very quickly. There are slow motion and quick motion ones but anyway it is quicker than GTO and both lines show low loss level. One MHz. is highest frequency, that is 1 million cycle and at this time the electricity is only 50 cycle, which is we are using now. That means you can operate it at very high frequency and still the loss is less than 1%. That means, if we limit the electricity at 50 cycles, we do not consider to limit ourselves to 50 cycles any more. So if you use high Hz. and transformer can be very small and motor can be small in size.

For example, if you would like turn off the record on audio player and that small size motor can operate train, that is theoretically, a very miniature motor can be used and the miniature size motor will contribute to the reduction of loss. 32mm in diameter, that is 3.2mm device and 300 ampere electricity can be generated. So you can see 4,500 volts now. In such a small device, you can handle very large amount of current, 1 million sometimes. Of course, for short term, 100 MW can be handled by this small device. So such a device can be used now.

People say that man is an animal to use tools. Many tools are available for human to use but most of the tools are inefficient. Efficiency of engine for car is nearly 50% of the theoretical value, only 50%. So the actual efficiency is 25% of theoretical value. But Japanese engine is the most efficient. It requires a lot of efforts to increase the efficiency level to 50% of the theoretical value. If we can operate at the theoretical value, the consumption of gasoline will be decreased to one-third.

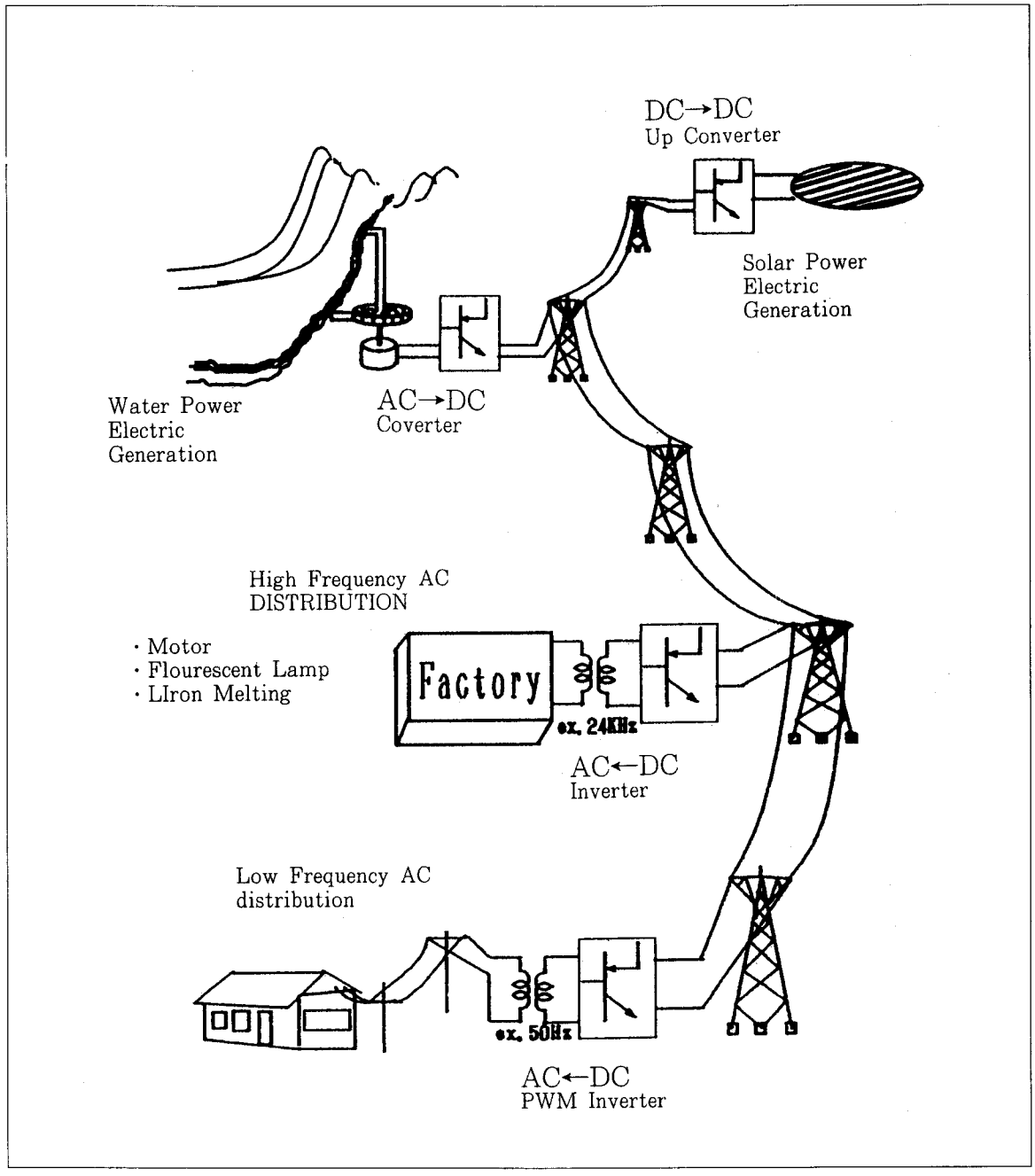
So a lot is expected to the research and development to increase efficieny. So the device to handle the electric energy is now invented and efficiency is 99% and more. There are 3 things which can be operated at 99% efficiency in electricity.

The first is Michael Faraday claimed by the British and Steinmetz is claimed by the United States. Anyway, one of those 2 persons contributed to transformer invention.
This transformation is the first best, efficient machine that people ever had, that is, 99% efficiency.

The second one is the 1 PMI diode which I invented in 1950, that is converter from A to D converter and 20 days later, G. E.'s Dr. Robert Hall disclosed these things are 18 days late, so our invention was 18 days earlier than them. So this is A to D, this is the D to D converter and efficiency is 99%.

Human beings use electricity by using transformer or converting from A to D or D to D. Energy conversion is now very easy for human beings. So, even if you distribute direct current and you can convert D to A at the consumer place, that is higher efficiency. And then through transformer the energy is distributed to plant or households. Transformation loss is only 1%, a total of 2% loss in this case.

So in Yangtze River at upstream, you can generate electricity. Please consider this as the Yangtze River and you generate electricity there with high voltage and then convert to direct current, it is called the DC power transmission. They use solar cell, again this is direct currency and then it will be converted through the converter. So this again is high voltage DC,



half voltage direct current. And this can be transported for 10,000 km.

When it reaches at the plant, it will be changed to AC, so DC to AC, and here at factory, it is not limited to 50 cycles, maybe 24 KHz., 24,000 cycles can be used in the factory. All the machineries in this factory will be miniaturized by factor of tens. So this is a very material saving factory. And here it is called 50 cycles and the loss is only 1%. So the total of 2% loss and we can supply electricity to the households.

Now, we are able to transport electricity over the distance of 10,000 km., and of course, the electricity will be reduced to 85% of the generated one. That means the loss is very small. In the future, at normal temperature, super-couductor may be used for industrial use and in that case, energy can be used 100%. That is for the future challenge of technological development.

With the current technology by transporting electricity about 10,000 km, only 15% loss. So we are now relying on oil and coal but if we can use this kind of electricity, you can supply energy without resorting to the use of oil or coal. If we industrialize semiconductor device which we invented and if we sell them, even resource-poor country like Japan can survive using such technology. And this is to the advantage of the people, because this kind of technology will not damage environment. So this is a future contribution of science technology in the protection of environment.

Last year in November, we were invited to a dam in China. China is making an epoch-making development, which is comparable with the building of pyramids in the past. China introduced us to two challenges. One in 20 years' time from now, they were going to close all coal fired energy, thermal plant and nuclear plant. And they were going to resort to hydropower generation. That is a challenge in 20 years' time.

The second is, if you build a dam that will destroy environment. In Japan, we have a very good dam that is idealistic in the protection of environment. We have Tadami River in between Sendai where I live and Tokyo and there are many hydropower plants in tandem, many, many plants. And energy is generated in one plant and that is distributed to the other plants and that is converted to energy and that is supplied to another hydro-electricity plant.

So if you use those plants in tandem, it will be more efficient. You don't have to reserve a lot of water. Instead of one big dam you can build 10 small dams so the water demand will be reducd not only one-tenth but to smaller amount. So the area which is soaked with water will be smaller and the size and depth of dam will be smaller and the construction of a dam will be cheaper. So rather than building one big dam, several small dams will be more idealistic for the preservation of environment.

In Beijing, before I visited the industrial dam, I made a lecture on this proposal. The leader of the Chinese people tried to explain to me as follows:

In Sankyo dam we are going to build a big dam not only for the purpose of power generation. China and the United States are big continents. If there is a flood it takes so much time for them to absorb water. Japan is a small country and if damaged by typhoon, it's small as compared to the flood damage in China. They are going to build a big dam and they will try to store water so that downstream people will not be flooded by huge amount of water.

When you say that hydro-electricity dam is to be built, many people would say that, that will spoil the environment. But if there is a big dam to preserve water it may damage the environment, but if this dam is a multi-purpose dam, then that will not necessarily damage the environment. Because that will save people from the damage by flooding.

I am not an expert, I cannot say anything, so I didn't make any comment. So you cannot say that dam always causes environment damage. The hydro-electricity dam may be smaller in environment damage as compared to the thermal power plant.

I have explained many examples of increasing the efficiency. Science and technology, it's an area which people are expected to play more important role and we hope that we can make bigger achievement by development of science and technology so that we can minimize the environment damage and maximize the benefits to the people. I think that is a responsibility of the people as a whole.

And if we can add spiritual improvement in addition to the material affluence that will be

our future. If you feel cold, you just turn on the heater, that is not enough. You can enjoy the coldness as well. So you can enjoy material as well as spiritual satisfaction. That is a new paradigm for the new value toward the 21st century.

We expect there will be a huge increase of population. We hope that people on this earth can enjoy both material and spiritual satisfaction by the development of science and technology. I think that is the target for the 21st century civilization.

Second Part-Panel Discussion

Reikici Shirane (Coordinator) :

Good afternoon, ladies and gentlemen. This is the Panel Discussion, the second part of the program of this symposium entitled "Paradigm Shift in the 21st Century."

In fact, those gentlemen on the stage are the super stars so to speak in each discipline. This is a prime opportunity for you to be exposed to those renowned professors and experts, so I would like to encourage all of you in the floor to join the discussion during the free discussion.

I believe the two keynote presentations set the pace for the discussion here, providing the foundation for the discussion about the Eco-technology and science and technology. As for the schedule, I would like to invite Professor Hamada as the first speaker. In the meantime, he is also involved in the TV program production at NHK, I would like to go without any reflex like Professor, Dr. or President. I will just call them "Hamada-san" and so on.

I would like to ask Professor Horikoshi and Prof. Mandelbrot followingly, then I would like to ask the two keynote speakers to give us the supplementary comments. I would like to give each Panelist about 10 minutes, probably that would be 15 minutes. I would like to remind them to spare some time for discussion after the first round. My role here as a Coordinator as I understand is to keep time rather than a coordinator or a moderator. I think I am merely the time keeper in this Panel Discussion.

In the beginning of the Symposium, Dr. Yoshimura of Honda Foundation spoke about the Eco-technology and in fact this is a rather familiar topic to all of us, nearly 20 years' involvement on the part of Honda Foundation, even before the birth of the Foundation itself. In fact, during the past two decades that this paradigm shift started to take form. From the Japanese point of view today as we are towards the 21st century and as we are now faced with the variety of problems, and we tend to make a projection about the future and whenever we try to do the projection, we try to identify some signs of changes. Because in retrospect whenever we look back the history we find out some precursors, signs, before major changes took place.

In '80s and '90s, those changes and events that we have witnessed are such that in 1985, across the globe some epoch-making events took place. For instance, Gorbachev came to the power in 1985, he advocated "Perstroika" and "Glasnost," the freedom of information, which were in a word a precursor of the collapse or demise of the socialist regime that followed in late 1980s and early 1990s.

Sorry to the American participants if there are any, but in 1985 at last the United States became the debtor country instead of the creditor country. I think since 1914, that the United States was always the creditor country lending money to outside world, as is symbolized by the word "Pax Americana," there was the role of the United States financing the various activities in other countries.

Therefore, in that sense again, the 1985 was a major turning point for the United States. They became the debtor country instead of creditor country. If my memorires are correct, since 1914, the United States always rendered support. Especially after the World war Ⅱ, they entered the Marshall Plan, a major support was provided to those countries that were

devastated by the war.

And in 1985, at the Plaza Hotel in New York, the Plaza Accord was concluded by the Ministers of Finance of the various countries, which culminated into the Plaza Accord that triggered yen appreciation. In 1985, the US dollar was about ¥260 but then in 1988, that is 3 years later, it became as high as ¥120. That is the two-fold appreciation so drastic just like the one that we are now going through.

Therfore, the low interest rate policy was implemented which persisted for too long probably due to the wrong projection by those concerned in the Finance Ministry. Because of the low interest rate policy, the so-called bubble economy blasted and then after the burst of bubble economy, the long-lasting recession started. There is no use of criticizing what happened in the past but as I said, it was 1985 that for the first time the ozone depletion and the environmental concern came to the fore, and at the international forum for the first time the environmental issues were placed on the top of the agenda.

At the UNEP, the United Nations Environment Program I think if I remember correctly, it was in 1985 that environmental issue was identified as of the high priority issues. And I think it was Dr. Roland in 1974 published the so-called "Ozone Depletion Phenomena" based upon the calculation.

But finally, in 1985, the UNEP raised this issue on the Agenda so it took almost 11 years until the ozone depletion and evironmental issue was placed on the top item on the Agenda. That was because such concern was considered to be not directly related to the environmental issues. If they were trade issues or economic issues, the recession and so on then people were willing to discuss. But the environmental destruction was not the issue drawing the attention of the world community, not until 1985.

So they were taken for granted where those were established as paradigm or hard to change. I think it was Thomas Kuhn, the specialist of science history who started to use the word "paradigm," and the word Paradigm became so popular. And now, this word paradigm is combined with the shift and paradigm shift has become quite topical just before the 21st century.

We are now questioning those that were taken for granted in the past, we are trying to review them objectively and if necessary we may be forced to make chages or so-called "paradigm shift." With that understaning in our mind, we would like to proceed with the Panel Discussion. I would like now to invite Mr. Hamada to give us his views.

Now, Mr. Hamada, please.

Takashi Hamada: Thank you for your kind introduction. I think you have received at the reception the gist of my talk here. Attached to that there should be 2 small charts which I will go to later on.

Professor Colombo and President Nishizawa have very rightly and poignantly talked about the need for the paradigm shift. I am an expert in the history of environmental evolution so from that perspective, I would like to talk more on the perspectve of the earth. My talk will be more for conceptual one.

Since the mankind entered into the modern science and technology age, substantial change was needed and the event that triggered this was the travel to outer space. To look at

earth from the outer space theoretically is understandable but to actually see it was not possible before. And the micro-gravity world expands that and the people would have served what occurs in the micro-gravity which is not existent in the human activities.

Having experienced this or having witnessed this, human kind became aware that we are under the dominance of gravity named 1G. History of science has often stated that discovery to telescopes and microscopes and other tools which have enabled human being to expand its view has endangered the change in the perception of mankind and in this context, we mankind was able to look at earth from outer space, serves as a point of transformation for the mankind in terms of this perception.

Development of science and scientific technology, of course, we all agree have been playing the major role in this change in the perception, but as we have been talking civilization also have had great impact. What we are now inclined to do is to change the paradigm, which is the change in value system and school of thoughts and perceptions and propositions. And in fact the result of this culminates into the paradigm shift and it may be simple and it may be familiar to you.

We have learned at the college that earth was the huge object but now we see that this is a small object. Earth was considered as stationary, the surface was not moving but now we know that earth's surface is constantly moving. And due to the information technology we learn what happens on the other side of the earth at real time basis, which has given as an element a new perspective to look the daily life.

Civilization has put its trust on science and technology so far in pursuing welfare of the human beings. But that is of the past. When you look back, the lifestyle has taken full advantage of science and technology in the past, and as Professor Nishizawa rightly pointed out, now faces the situation when one has to look back whether it was right.

It is, of course, we all understand that science must pursue truth and principles. But once it comes into the realm of technology, in other words, once it comes into the realm of serving the human beings, it changes. And human being is the most intellectually developed being and human being tends to pursue high level of amenity. In other words, when higher standard is achieved, human being cannot reduce the level.

So all the other lives on earth other than the human beings have been affected because all living beings, apart from human beings, are dominated by food cycle which is different from that of the human beings. In other words, human beings have made its own food cycle which is different from that of the living organisms other than human beings.

There is also a major issue of population increase. For species under the virtue of the reaction system, all organism on earth in harmony with the environment and that is exactly the reason for the existence, in fact the reason datum of all the beings there except for human beings. That is to say that we human beings have been focusing on science and technology then all of a sudden we realized that there were certain aspect of unpredictability or the discoveries and development advancement which the certain technology has achieved is only a small fraction of what exists. This is something we must reflect upon.

Having said that, we are the most intellectually highly developed being and we cannot reduce the level of high demand and one tends to be egoistic in looking at the environment.

For example, take the term "waste." That does not exist in the realm of environment or

nature. It is an arrogant perspective of the human being to create waste. I think it is important that we should look back and reflect upon what we human beings need to be objective in looking at the human beings and I believe that this would lead to the paradigm shift.

In 1950, a British named Lancelot Law Whyte, who is the morphologist and he said that if the natural science were to fail in the understanding of morphology which is known, for example, morphology of optical, you cannot express that mathematically or quantitatively. And if morphology cannot be expressed, that is only because the issues that the science is familiar with is not as complicated as that of the morphology.

In other words, science does not identify many of the aspects of nature as we would like to think so the point here Mr. Lancelot Law Whyte is saying that we don't know all that much. We must be modest and reflect back and I think that this approach needs to be incorporated in the global policy addressed to sustainable development.

So far perhaps I am saying too much, but we have concentrated extremely on the production side and there was little thought given to waste, which generate from production. In other words, I think we have been too short-sighted seeking for the amenity of the immediate future. But then we found that there was a negative impact, which is beyond our imagination and I think most people regret this fact.

Allow me to be abstract. I have written the word SDP, which stands for slow down policy. I believe it is necessary for us to address the slow down policy. We do have economic basis now. Let's go back to the primitives. I am not saying that you cannot survive. In other words, we will maintain the production but at the same time, we will also grope for a path of survival in order to achieve balance between human activities and environment.

I have given you the chart of SDP/ACT system which I advocate. This is the system whereby econmic activity to the extent necessary, by necessary I mean from the perspective of earth to slow down the economic activity as much as possible. So the pace of development will slow down so the way to do that is to seek for after-care technology which strives for recovery, the assembly and recycle and after-care is to look at the prognosis, meaning that we should try to maintain sustainable development of the earth through ACT.

We should not unnecessarily change the environment and when we have gone through the development, we have found that negative ramification has been generated. Maybe it's good for the human beings but not for the others. As a result of that, we now see environmental destructions addressed the ozone hole issuses.

I made a suggestion in Germany the other day and it was supported by many. That is the creating of the bypass through the creation of SDP/ACT systems so that energy consumption will be minimized in order to resolve the exisiting issues. This is the system. It's a simplifying system. There are many problems involved here and the reason is that because the human beings are animals who strive for intellectual advancement and refuse to go back. Whether the human beings are willing to go counter to the development in order to protect the earth is a situation that we now face.

I do have another primitive chart which shows the evolution of the relationship with the human being and the nature. Much has been said about that. When there were few population on earth, the life was primitive. In other words, it was natural way of living organism but as we experience huge population increase we have been harsh to the environment. In other

words, it's acquistion of resources.

There was a talk about dam. Numerous number of dams were constructed for different definition to dam so this requires a discussion. But we must understand that resources are limited and that there must be a limitation and there must be harmony between the human being and the nature. It is important that we recognize that so that priority was given to the environment in the primitive time, which then shifted to priority on the human being. But what is required now is the shift from the both, that is an objective perspective to find the way for the human being to exist togther with the environment. And here lies the need for this paradigm shift.

Thank you very much.

Rikichi Shirane: Thank you. You pointed out that the nature is hard to grasp. I would like to ask Mr. Mandelbrot later on to comment on that point. But before that, I would like to ask Mr. Horikoshi to give us his views.

Koki Horikoshi: Good afternoon. Can I use the overhead projector? I didn't expect that what I was planning to state was exactly covered by Mr. Nishizawa. But please allow me to be somewhat redundant of what Mr. Nishizawa stated.

I just want to show you how flexible the Japanese were since old times. So allow me to give you the talk which is somewhat different from what I originally prepared for it.

The bio-diversity is one of the hot terms that is often used. That is diversity of species. It seems as a matter of course, to the Japanese but not just scientists or the biologists have hard time in understanding this fact, biodiversity. The God diversity is the word that I coined.

As Mr. Nishizawa rightly pointed out in the past, we believed that God resided in every matter. Even the human could be the divine presence after they passed away, but also the animals, fox for instance became God. For the husbands, the "yama-no-kami" or the mountain goddess is in fact your wives.

So those matters are respected, they were respected with all and were considered to be the God. But you have to be careful in dealing with the divine presence. In other words, you have to be right in making a choice in asking for the favor by God. In the past, Prince Shotoku Taishi stated, "harmony should be respected." Harmony is most valuable. In fact , that is the under-lining philosophy for the microbiologists. Think of "sake." That is a unique product, that is the yeast and lactic acid and they are concocted. They are not isolated in a mix, but rather they are concoted.

So that those microorganism react or inter-act with all and each other. Sometimes they help each other, while in other time they may be controlling each other. The human involvement is not to kill the micro-organism. This is a very unique way of making "sake."

But after the Meiji Restoration, when Japanese became so enthusiastic and eager in learning from the West, we invited a German scientist in the field of micro-biology. In face of the lifestyle of the Japanese which looked so filthy to them, the German scientist criticized that the way of making "sake" is so filthy that the "sake" could not be made and he taught the German style. And of course, "sake" was not made.

In the case of the "sake" maker, we use certain sort of Fungi and during the

fermentation process, it is transformed into the yeast. In view of this, the German scientist thought Japan was a unique country, probably the kind of Fungi would spread into the yeast, he wrote in his report. That was just like a very funny way of the association that the tradition of the Japanese used to have.

So the wrong Fungi is spread into the yeast and he published his report in the academic journal back in Germany. Because he thought the Japanese way of making "sake" was somewhat mysterious. But anyway, that was how the micro-biology was developed as the academic discipline in Japan.

What was the consequence? The western style micro-biology developed then about 20 years ago, the microbiology faced the stalemate. Without the drastic paradigm shift we cannot expect the future for micro-biology. I'll tell you why. That is related to anti-biotics which is so familiar to us. The researchers were desperately looking for the micro-organism that was beneficial to the mankind.

But probably we were too arrogant and because we are man-centered, we thought that probably there was no useful beneficial micro-organism in the world. But the question is how many micro-organism we have ever identified so far?

As you can see on the screen, look around yourself. Try to find out how many micro-oraganism are, for instance, in the garden or in the farmland. How many micro-organism is there? And how many can you count and recover them. That could be the kind of the marker or index to indicate the progress of the science. Within one gram of soil, there are about 10 to 9 number of micro-organisms. But in fact what we have identified so far are 1 to 2 magnitude smaller than that.

Mr. Nishizawa said of 99% efficiency. I really envy them. In other words, we cannot recover 99% of the micro-organism that are contained in one gram of soil. Then turn to the ocean, which accounts for two-thirds of the globe. How many micro-organisms are there in the sea water? There are about 10 to 3 micro-organism and again, a recovery ability is so limited that we can recover only a part of them. There are so many unknowns in the micro-biology.

Therefore, we should be more prudent and not to declare that we have faced with the limit. Then there is a very pessimistic point of view. I am sorry this is rather hard to see. The E. coli is often applied in the electronic engineering. DNA of E. coli has been studied intensively, but we have identified the nucleonic acid sequence in the DNA of E. coli. But we succeeded to some extent in the case of mankind.

But once again turning back to E.coli and it's sequence of the nucleonic acid, which is about 2μmm long, and again we have identified only 50% of them. In fact, it has been developed and accumulated in the past 3.5 billion years. In other words, there are so many pieces of unknown information that were stored in the past at 3.5 billion years. Furthermore, in the world of biology we tend to be man-oriented. If you look back the history of micro-biology, you will readily find out that in 1868 that Pasteur established the foundation of micro-biology followed by Cock and others, everything started from man. That is, body temperature of 37 degreeC or the temperature of food that is available to the human, and such and such. In other words, the point of origin on the coordinate system is always a man so that everything out of that range was considered to be unusual.

We have been so arrogant. In other words, every living organism has a different requirement. Every living organism has a right to be the center of origin. But in fact such a viewpoint was not accepted as a normal way of thinking as extreme. Think of that word again. The word extreme also indicates that it is a discipline centering around the mankind. It seems like I am the author responsible for quoting this word.

But anyway and finally, extremophiles has been established as one of the disciplines. and 90% of those living organisms within this discipline are unknown. That means we belong to the minor of the living organism including those that are using. We are not the majority at all.

And the question is how we can develop this discipline? In the first part, one of the speakers referred to science and technology agency and its project, ERATO. The superbugs project is what we have been promoting. As was 1985 until 1990 the program was implemented and that program led to the discovery of Dunor's living organisms, some of which are so closely related to our life and contributing to enriching the quality of life of the mankind.

Some of them contribute to the composing, it was chemicals and compounds that are hard to degrade in the natural environment. And in fact, they exist in the natural environment nevertheless our eyes were closed to such a phenomenon. We did not realize that exist. And such an idea was reported since June this year at the European Union and the superbugs project of EU initiated.

We are happy to see that our idea was applied to the European scene and they are promoting their own program. So why don't we broaden the scope of view. It was why since 1990 at the Japan Marine Science Research Center, the Deep Sea Environment Study was started. We know that the ocean is where the life started. Therefore, we expect that there may be those successors of the progenitors of the life in the deep sea and it is called the Deep Star Project. I am in charge of the project as a Director and in fact, I will tell you that deep sea ground in the deep sea is such an unusual environment.

It is subject to the extremely high pressure as you can easily understand. The "Shinkai 6,500" is the submarine that can go down to 6,500 meter deep. Inside of this submarine is kept at the a atmospheric pressure so that it is quite comfortable and soil and sea water are sampled for analysis underwater. We are extremely intersted in how the living organisms can survive despite such extremely harsh condition of high pressure.

This is a sea shell on the sea bed in the deep sea. In fact there are numerous of them. The atmospheric pressure is hundreds. In other words, they do not stand against that high pressure but rather they like that atmospheric pressure. If they are viewed from the human viewpoint, such an environment seems quite unusual but for them, such environment is so comfortable.

We think of the micro-gravity. If they were the living organism surviving in the microgravity, what will happen to them if they are brought down to the earth or from the zero gravity environment down to the earth. what will happen to them?

You may ask why I am so much interested in such an unusual environment. That is because the science in the past is centered around the man and it turned out that the man-centered science could not expect much progress because of so much unknown around us.

That is why we need to change our perspectives trying to identify those living organism, living in such an environment and in fact, we are co-existing with them so we need to pay respect to their lifestyle so to speak.

Newton once stated that we are just like children playing around on the sea shore. We are so happy to collecting sea shells even if we are faced with such a big ocean with much potential. And we are just like that and I like that phrase by Newton. Thank you.

Reikichi Shirane: Thank you . Dr. Mandelbrot, you will be the third speaker. His Fractal Geometry was the first book translated into Japanese and Dr. Hironaka translated that book into Japanese. He is the mathematician. I asked him, what is "Fractal theory" from the viewpoint of mathematician? And a good answer came from Professor Hironaka. He said seeing is believing, and he said seeing is proving. So to see is to lead you to new discovery. So Professor Mandelbrot has made a lot of discoveries.

I am a Vice President of Japan Computers Graphic Association and he is a great man in the computer geographic as well. So I hope that you will enjoy Dr. Mandelbrot's presentation. I will give you 15 minutes, Dr. Mandelbrot. Would you please start your presentation.

Benoit Mandelbrot: Thank you very much. I would like to make some comments which will not repeat what the previous speakers said, and what I would like to emphasize is not the paradigm shift in the needs for science but the paradigm shift within science.

Now, the word "shift" here perhaps be put in plural because depending upon which field you are examining, the shift takes a different character. Now, first of all, there is a shift which is coming now very strongly, extremely strongly and who are the scientists? Because one should never forget that science is done by humans, and humans are not given once for all as untouchable creatures. They depend very much upon the environment in which they have been trained since their early ages.

Once upon a time, only a hundred years ago, pictures were very difficult to make. Before photography, you had to paint something or draw it extra hard and expensive and pain causing process. The word, the printed page were much easier. Therefore, learned persons were trained almost exclusively on written text.

The idea of science became written text. By written, not only words and languages like Japanese or English, but also formulas. It's a language which includes the common language and also mathematical symbols. But this idea had nothing intrinsic about it. It was due to some extent which I don't want to judge, to the environment in which research had to proceed. Pictures were difficult, expensive, hard to obtain and hard to handle.

Now, let us jump immediately to the present time. Everyone complains that children see too much television and many people complain that children play too much with computers. Well, why complain? Of course, too much is too much but this matter of playing with computers echoes that phrased by Newton which was mentioned just a few minutes ago. The essence of learning is playing. By playing with computers humans become different from what I was, from what my father's generation was.

By the fact that at present, photography, the computer, the television and so on provide us with the extraordinary wealth of visual experience, is bound to change the nature of the

people who are going to do science by the beginning of next century. Where new people come, they will do science differently. I don't say they will do it better but they certainly will do it differently.

Therefore, a shift is absolutely inevitable. Whether one likes it or not, science can not be the same at the 21st century or this century, because the people who do science are different. No child can grow in the present environment and isolate oneself from television, the computer, from photography, from everything, from publicity, etc.

The question next arises is, what science will these new scientists be doing? Well, there again, they can do science of a much more demanding nature and by happy coincidece, of a nature which I think is going to be very helpful for the viewpoint of environmental, ecological aspects which were discussed previously.

For example, in all the charts about defects unfortunately referred to technology, one has the matter of extent of pollution but what does extent of pollution mean? For example, if you look at the harbor, if you need the average proportion of hostile micro-organism in the harbor or the average proportion of heavy items which are dangerous, copper and so on, in the water of a harbor.

Is that average meaningful? Is that average useful? Why bother about the average? Well, we bother about the average for many resons. In some cases, it's all that matters. In all cases it used to be all that you could afford to look at.

A hundred years ago, the statisticians had tables of logarithms to work with or perhaps very primitive hand type-writing machines. To compute an averge was already a big effort. It was quite a big achievement to compute average and say this harbor is dirty than this harbor because the average of micro-organisms or the average of copper is bigger one than the other.

However, I am sure that the harm done by pollution is not only a matter of average. If pollution in one case is extremely concentrated, even though the average is very low, if it's clumped in small places, those small places can provoke extraordinary dangerous effects.

Now, we change the topic slightly but only slightly. A few years ago, maybe 10 years ago, 15 years ago, when we had this terrible fear of atomic war, the scenarios made with nuclear winter, nuclear winter which corresponded to the fact that an explosion would occur on earth, atom bombs in large numbers and the dust will go up and cover the sun. And a rough calculation gave terrifying results.

Well, this rough calculation was totally meanigless. I hated the thought of atom war as much as everybody else but I could not take serious this calculation. Because why should it be that the dust provoked by atomic explosion will become uniform of the earth. It's almost impossible. Clouds are never uniform, nothing is uniform. A big clumpy cloud of dust consider one place, may have very much different effect from the same lot of dust distribute uniformly over the earth. And I am pleased to say again, not as pleased as by the fact that the fear of war has become lesser. But it was in the context of fear for war. I am pleased to say some of my pictures of clouds, my simulation of clouds were used by some scientists to try to get more realistic picture of what would happen in case of atomic warfare.

It was simply realistic because of better science. The science which was geared towards these phenomena as opposed to being geared towards the averages. Later on, another

question arose again. Is it true that dust is going to reflect light and prevent light from getting down and provoke nuclear winter?

Well, all my friends made a very careful calculation and found that it was not necessarily true. That dust is not just here to seal, the particles of dust actually are factor, actually have very complicated structure and depending upon where dimension of the structures is lesser to or greater than to, the effect of percntage of dust will be completely different.

That is a very important distinction. I am not trying to say that everything is fractal in the world. Please don't misunderstand me. I am sure that there are fractal everywhere and if you look in some areas or another and you will find some aspects that are fractal. But in many cases, those aspects are not important. In other cases are very important.

But perhaps again we come back to this question of what kind of science one needs in order to understand the questions of ecology, the questions of structure of environmental pollution, the effect of the measures taken to diminish the pollution? In order to evaluate in a rational fashion or somewhat rational fashion, there is very important question. One needs a science of disorder, a science of Messias which applies to this phenomena.

And again, as I said a few minutes ago, the averages very often tell very little of the story. Averages are very misleading. In physics, the physics which was triumphant quite generations ago, the physics which I learned and physics which came immediately afterwards, the bulk of that physics was concerned with phenomena in which averages and style of deviations were actually all that counted.

Well, physics being successful, there was what you can describe as "physics envy" a kind of imitation of physics which came naturally whether countless or not, sometimes for lack of anything better. If you have read books of mathematics, books of statistics, books of randomness, all you had was physics. Therefore, that all you had are supposed to apply to the phenomena which one was trying to understand.

Those tools I think were not adequate. For the purposes of better understanding, better control, better description of the world, better description of the effect of technology over the world which surrounds us, I think more refined tools are necessary. And again, it is not only a matter of saying that proportion of micro-organisms in this harbor is so many per millimeter is very important but you must then say, are they clumped or are they very diffused? Is copper very clumped or is very diffused?

If you have the river like the Hudson River in which extraordinary efforts were made to purify the Hudson River is in New York, of course, it ends in New York. Now, this river was polluted by PCBs as here and the question arose, should one get them remove the PCBs or is it going to be worse by trying to remove them because the amount which is stirred by moving them ill make the river even more dangerous for many viewpoints. Again, a very much more accurate and more demanding description was necessary.

Now, let me move again to pick up the question of dams. For many years, I was very much intersted in the question of the effectiveness of dams. Not so much of dams in the rainy parts of the world because they are actually rather predictable. But of dams in semi-arid parts of the world. Now the great difficulty is that a dam which is built too small and is always full is not performing the function. A dam which is built so big is always empty also performs a function. Therefore, the size of dam is something which required very careful

thought.

Naturally enough, a very brilliant man arose, his name was Hurst, he was an Englishman of mediocre scientific background. He was the graduate of Oxford but not a very brilliant graduate, but a mind of profound respect for the complexity of the River Nile. And so he spent his life as an official of the English civil service in Cairo studying the Nile. He was also making grants for the Aswan High Dam. And he realized that the Nile was just not only quantitatively more complicated than the fluctuations that one was used to deal with, but qualitatively more complicated.

You could say in my current vocabulary, which I try to make simple to make it very strong, that the randomness which the hydrologists were thinking of when designing dams was a mild form of the randomness. The Nile presented a wild form of randomness.

Well, a very interesting example of the encounter of wild randomness and the public policy occurred a few years ago, I think 10 or 15 years ago. Some time before, the State of California, the State of Arizona and Mexico, an independent country, the 3 of them had tether written to divide the waters of the Colorado River, which goes through the High Rockies and then goes down and empties in the Gulf which is between Baja, California and Mexico.

Now, they divided these waters on the basis of the best knowledge available at the time and that this knowledge unfortunately was a slide wrong. They said, well the amount of water per year is so much because in the last 10 years the Colorado River had water. So let us divide that and California may take so much percent, which makes so many cubic meters of water; Arizona takes so much and Mexico takes so much.

Well, catastrophe came immediately. For the next 30 years, the River Colorado had much less water than predicted. Having divided each one to take its share but that was not enough for everybody. And rather rare event in the annulus of politics. The diplomats, the lawyers had the necessity of bringing a rather practical engineer who happened to be very brilliant and very spectro-facts to explain to them that this tether was ridiculous tether because it was dividing something that didn't exist. That the water going through the river is not a very little quantity. And he had to remind the politicians of the story in the Bible. I am sure you have similar stories in the Chinese mythology, the story of the seven fat years of Egypt, followed by 7 lean years of Egypt. The dream of Pharaoh and the story of Joseph, son of Jacob, son of Isaac, that he saw a dream that for 7 years the country of Egypt will be very prosperous and then for 7 years great dryness will come and to prevent this dryness reserves of grain and everything should be accumulated by Pharaoh, otherwise his subjects will die of hunger.

Now, the history of the River Nile is very well known. Because it was so important that records were kept. Besides if one doesn't want to stick to the River Nile particularly but just know the history of the amount of water going down in some parts of the world, one has the record of thickness of the rain in trees. So note one knows the wet in Arizona for 6,000 years very accurately from year to next. Because of some trees that grow to be very, very old, they are not sequoias, not beautiful. They are shrub-like trees, they live very,very old and then don't die during dry periods,which is why they are so good for this purpose.

Well, this history shows an extraordinary wildness in the fluctuations of the climate. So in terms of policy in building a dam the consensus became that to build a dam is not only a

matter of computing how much water goes through it, because if one does not take account of the wildness of the fluctations of the water from one decade to the next, if one forgets the history of Egypt which had rich dynasties and poor dynasties. The rich dynasties had plenty of water and built pyramids and the poor dynasties had no water and did nothing because they had difficulty in surviving.

If one forgets all of the complications, well, the dream of having technology and environment mashed together which is your dream, my dream, everybody dreams here, that dream could not be fulfilled.

Therefore, I have sketched two paradigm shifts, which I think are important and I think are happening. One of them is that the tools of scientists have changed. The person sitting here are, of course, not hard physicists or hard mathematicians who have denied the importance of the eye. So I don't have to preach to that to my fellow Panelists. But among my colleagues in mathematics and physics to preach the virtues of the eye was sometimes very difficult. I think it's going to gain very much and I think whatever my colleagues believe, the students, the young people are going to be different. They will use their eyes because eyes are so much more powerful than any other means of communication. It is not the only means but it's a very powerful means.

And the same persons are going to be faced with questions which their parents, my generation and before never had asked from them. For example, it was perfectly possible that someone who have a brilliant career in physics and never worry about anything except about averages of the first and second order, that was enough. That is not enough as I said in several forms, for the aspects of environment we faced with when we tried to understand the environment and to fated environment to make technology fit for the environment. If you want to see whether change in technology will diminish considerbly the harm done to environment, we must be able to measure this harm. We must be able to assess its dangers.

Therefore, I believe very strongly that science which has been practiced for 30 years, for example, were different in many qualitative ways from the science of today. Not only quanitative ways, I am going further but qualitative ways of being different.

One last comment. The extraordinary prosperity of science in my generation has had many unexpected results but one of them I think is the following.

The scientists became so numerous in my generation, that some problems would have taken 60 years, 100 years over were solved very, very fast. As a matter of fact, a common problem to my colleagues and friends was how rapidly their contributions in science were absorbed and viewed as being well-known routine all had, how rapidly a new idea roll and in a certain sense, completely understood.

Well, this rapidity means that perhaps progress in those areas will not continue at the same rate. I don't know, I say perhaps, nobody knows. But one thing is clear is that other questions are very pressing nature will be thrust upon scientists. I think that the society which has the right to at least no other scientists are doing, has the right to ask the scientists to explain what they are doing, will ask them to look into techniques for understanding the environment which will be necessary to put in practice the older thinking that was presented to you previously in this Panel and in the Plenary lectures.

Again, to conclude, let me repeat ending with the words which I was introduced, that the

fact the scientists will be different that they will be much more eye-dominated, much more demanding in the quality of the prediction of science that aspect will also be very important. That aspect also will diminish the kind of segregation in science which existed in my generation. The pharmacists and physicist and natural scientists and naturalists were totally different people. Natural scientist like my neighbor would, of course, never say the eye is not necessary. The eye is a tool for observation of life everywhere.

Mathematicians and physicists were not using their eyes very much in ancient times. They will. Therefore, I think the more unity among the scientists, the terrain and unity will be realized, will not be the terrain of abstraction for everyone but of concreteness for everyone. Thank you.

Reikichi Shirane: Thank you very much. We have already heard speeches from Professor Colombo and Professor Nishizawa. Perhaps the two keynote speakers would like to add something to what they have said having listened to the 3 Panelists. Professor Colombo, would you like to supplement in addition to what you have said?

Umberto Colombo: Mr. Chairman, I think the discussion up to now has focused on the need for a shift in paradigm, in paradigm of science and as Professor Mandelbrot has just pointed out in his brilliant intervention, of paradigm in technology, in economy, in society. And I want to just stress a few points to indicate that I also agree that shift in paradigm is absolutely desirable.

First of all, I think that we cannot conceive a long-term sustainable development by extrapolating on our past trends. Population is going to at least double once again before it is eventually stabilizes around the end of next century. We are now 5.7 billion people and the most accurate estimates of population leveling indicate that a stabilization in population for various reasons which I cannot explain here, will take place around 12.5 billion people.

That is, we cannot avoid unless we imagine dramatic tragedies at the world level a further doubling of population. Also, the per capita income of the developing countries in the world will have to increase. Now, there is a dramatic gap between the rich and the poor countries. We have about 800 million people in the third world at the threshold of hunger, living with a very low per capita income and this is going to change. The need to improve the level of life, the quality of life will mean that in those countries the per capita income will increase. Again, if it doesn't we are going to have big tragedies.

At present, each individual in the first world, that is in the industrial world, uses 10 times more energy than his or her counter-part in the developing world. About on the average 5 tons of oil equivalent vis-a-vis .5 tons of oil perannum. But if we take the extreme cases, there are gaps in the order of 1 to 50 or more and these are intolerable.

Also, I want to point out that the twenty-three percent roughly of the total world population that lives in the industrialized countries are responsible for 3 times as much emission of carbon dioxide and greenhouse gases as the remaining 77% of the population that live in the developing countries. This is clearly intolerable.

We live on a stock of energy essentially constituted by non-renewable fossil fuels that has, as was pointed out by one of my colleague speakers, accumulated during geological times and they are by definition non-renewable limited, so in spite of what the market now

tells us, by the way, the market is a very bad adviser, because the market reacts on short-term signals. Therefore, the market tells us this moment that because we have oil enough for 43 years at present level of consumption, gas enough for 60 or more years at present level of consumption, coal enough for 233 years at present level of consumption, in average fossil fuels enough for 106 years at present level of consumption. The market tell us go, consume, waste, and the signals are low prices for fossil fuels. And therefore, increased consumptions, increased emissions, increased possible danger for the climate of the future.

These cannot go along for a long time. I believe, therefore, we need a shift in paradigm and I believe that it is the north of the world, the industrializd countries of the OECD that have the know-how for much more efficient technologies in energy use and in the use of materials and that are going towards what I described in my lecture as a process of dematerialization of the economy. It is up to them to develop technologies and diffuse technologies that are more respectful of the environment that are really Eco-technologies as Mr. Honda devised with his imagination in 1977, following the suggestion of Professor Aida, of course.

We know now, I want to stress other point, we know now that the developing countries are unable to absorb even the technologies that are known well now in the industrialized world and well diffused. They do not use these technologies because, first of all, these technologies are not transferred as they should be by the first world, by the industrialized world. And secondly, because often third world countries have different priorities.

If the country is growing very rapidly and it is urbanizing very rapidly, they will not care so much about the very long-term future. They will care more about what they can construct now for population which is rapidly increasing, which is rapidly displacing towards urban conurbations that are becoming really very complex life systems.

So I think that what we need is a massive cooperative effort in the world whereby essentially the industrialized countries work and try to put at disposal of the non-industrialized countries the best possible technologies for transfer, the best ways to carry out their development. But unless we live in the industrial world a sustainable pattern of life, how can we preach the developing countries that they should not really adopt the same pattern of development that we have used historically. We cannot, in other words, preach or tell the developing countries what they should do unless we show first, that we are able to re-orient our pattern of life of industry of production.

There is, therefore, a need to embark ourselves in a massive effort of transformation of our productive economy and here I want to say just the last comment of my remarks.

I think we should plod to the decision that has been taken by the United Nations University that hosts us today, this afternoon, to support the so-called zero emission research initiative, proposed by Mr. Gunta Pauli. This is an initiative aiming at achieving or getting very close to it a most ambitious objective. The remodeling of industrial systems, characterized by a so-called total throughput that is an industry where total input equals total output. This seems to be an unreachable limit but we can go very, very close to it by regrouping industries and clustering industries in a decentralized manner in such a way that the wastes of one industry may be used obviously developing appropriate technologies, as raw materials or inputs to another industry. And possibly, we can do this by recycling the

wastes in an almost closed economy.

I know this would be going against the second principle of thermo dynamics which is impossilble. But let's remember that the earth is not a closed system. What we must do is to start living out of a stock of non-renewable energy sources and start living of a flocks. The flocks of energy that reaches every year the surface of the earth from the sun. Actually, the sun conveys to the earth about 1,000 times more the energy that our planet is using.

So, the problem is, if we can live out of this flocks, we don't need to exploit the stock and thereby increasing the entropy of our planet, because the entropy of our planet can live out of negative entropy which is in a way produced by absorbing energy that reaches us from out of the planet, that is from the sun.

In essence, President Nishizawa earlier mentioned of hydro-electricity as possible solution that would be ideal because if we were to exploit all the hydro-potential, we would have enough energy as we spend now. I do not go as far as he goes although there is a lot of truth in what he says, but idea is the same. Hydro-electricity is after all the product of the sun energy that evaporates the water and then the water becomes rain and then the rain becomes running water that can be exploited by producing electricity.

But there is also photovoltaic energy that is biomass. There are many other ways direct or indirect, wind power in which can really use energy that comes directly or indirectly from the sun. And finally, there is the possibility of creating the sun in the earth by on the long-term producing solar fusion energy, that is practically infinite source of energy.

So to conclude, we need really to shift paradigm, the sustainable development is not only a problem of the developing countries, it is both developing countries and the industrial countries and the less we give the good example by moving towards a sustainable development in the north, I do not think that we have the right to pretend that developing countries move towards a sustainable development themselves. And that will be the ruin of our planet.

So let's be wise, let'swork altogether towards this shift of development which will mean a great contribution from scientists and technologists throughout the world.
Thank you

Reikichi Shirane: Thank you very much. President Nishizawa, please.

Jun-ichi Nishizawa: Much has been already said by all the Panelists so I can be very brief.

I would like to propose different perspective, probably the different coordinate system. Let us suppose that we are faced with the starving child who is about to die. What do you do? Probably you will share your food with him so that he can survive. But he may be able to survive now but 10 years from now, what happens to him? He may be starving again without food. Can you just stand and ignore even when he starves to die? Which is more cruel to him? Do you think he is happier if he can survive now but he would die eventually 10 years later? Or he may be happier because he is now unconscious and he is a small child so let him die? What do you think? I want to help him and save him on both occasions.

In other words, we have to be giving aid or donation in a responsible manner. The aid that is provided by the advanced nations is sometimes made in such a way so that the advanced nations try to find an excuse not to give an aid and the neighboring coutry, that is

China, they promote a policy to limit a number of child to one. This could be regarded as against the humanity. But if I put it differntly, what happens if they do not limit the number of birth? Then in that case the population may explode even more drastically so that they may eventually suffer from shortage of food. In other words, they dare to launch a policy against the humanity in order to prevent the disaster of the humanity that could happen in the future. And there is a reality in the neighboring country. We cannot just sit and look at what is happening.

In other words, now is the time when the science and technologies are expected to make further contribution. In other words, the people on the globe have to think of others and dedicate our efforts to contribute to the welfare of others. I would like to be more specific.

There is a certain organization which I belong to, and this organization is involved in the studies of the issues of global scale. What I mean is that there are experts and specialists of individual disciplines. And they are good at their disciplines. And whenever you ask which is most important then those experts and specialists state that that is their discipline.But sometimes later you find out that, that is not the case.

That is why the inter-disciplinary coordination of the work is necessary. I could call this a system science. For instance, when energy is consumed the carbon dioxide is emitted and what is the impact to the mankind? Or what about the impact to the economic activities? How can you answer those questions?

Japan is resource-poor country so that without the industrial development, at least half of the population of Japan would die. So that means we need to keep on consuming energy in order to survive. Then what the Japanese should do in seeking for the alternative energy sources? That is why the global perspective, the global scale point of view is necessary.

For instance, deforestation is a serious problem. And some people insist on not killing even a single tree. But in fact, in my opinion, once the tree grows to a certain extent, the thinning has to be done in order to maintain the healthy growth of the forest as a whole. Thus the disciplines have to interact with each other and have to seek for further progress through inter-disciplinary approach. Thank you.

Reikichi Shirane: This completes the first round of the presentation by all the Panelists. It is 5 o'clock sharp and probably we are supposed to conclude the discussion around 5:45 or 5:50. So it may be a good time to receive questions or comments from the floor.

When you ask the question, please make sure to whom the question is addressed and also identify yourself, please. Anyone? Yes.

Hirohisa Uchida: I am Uchida from Tokai University. In fact, I would like to ask this question to all the Panelists. About the universality of science and technology, this is a commonly accepted view regardless of religions of different countries. But on the other hand, though not much has been said in this forum, the information technology and communication technology are considered to play a key role in the future society. And now that the communication network covers all the globe, for instance, satellite can help us to understanding what is happening to the global climate and also the communication played a key role in destroying the Berlin Wall and eventually leading to the demise of the Communism.

And now, we are living in the world with different value systems and when, for instance,

DNA control experiment is conducted, for instance, depending on where this experiment takes place, I think the way it is judged or the way it is evaluated would be different. Just like Mr. Nishizawa stated the cultural background plays a critical role in making certain decision required.

In other words, probably in the future we will face with the urgent problem of harmonizing the science and technology and the different cultural background.

Reikichi Shirane: Can anyone in the Panel answer the question?

Jun-ichi Nishizawa: Let me start off about the fiber optic useful communication. I am the one responsible since I was involved in that project, I would like to share with you my view.

I believe human cannot change his philosophy, for instance, for 2,000 years Jews are struggling to return to their homeland regardless of the damages and disasters that they caused in the course of the history.

For instance, Bosnia and Hercegovina, their sometimes crazy behavior is witnessed in such a turmoil if it is viewed from a different value system. In the history of the mankind for the first time with a help of a handful of engineers and scientists the science and technology let through historic change.

Let me use a different example. One company has a warehouse in Osaka where the other company has a warehouse in Tokyo. If the first company has an order in Osaka, in that case, even when they will deal with the same goods, same commodities they have to ship them from Tokyo or vice-versa. It is a tremendous waste. So with the help of the fiber objects, if they can communicate with each other and exchange information about the level of inventory then they can more effectively ship their products.

But in fact, the philosophical aspect is even more difficult to deal with. Therefore, to understand each other is so important. For instance, in the case of the United Nations, sometimes they do some commendable deals but in other occasions they are not. For instance, they easily resort to the forces to resolve the conflict sometimes. In the first place, they should try to facilitate the mutual understanding of those who are involved in the conflict.

Therefore, I believe information technology and communication technology can make an enormous contribution in resolving the conflict resulting from the mental aspect, that is the philosophical, spiritual differences.

Takashi Hamada: Mr. Nishizawa just answered the question. I think that answers is quite adequate. I agree with him more or less but I like to broaden the scope. The culture is diverse, that's the hard fact and no one can deny because of the historical background. And culture is born out of the localism and the way it is viewed is different from region to region. When the communication network expands all over the world, without the paradigm shift, such communication network can only increase the friction.

But sometimes, if the conflict evolves into the issue that can decide the life or death of the mankind, that is when we are required to make significant paradigm shift through better communication. In other words, it is not the ethics of the mankind that can determine such an important question but rather the ethics of the earth is playing a decisive factor and

paradigm shift can contribute to it.

Mandelbrot: My footnote. I believe that as we should preserve bio-diversity which is a very important characteristic of our world, we should as much as possible try to preserve cultural diversity. I believe we have a world rich of different cultures, each of them can contribute to the progress of mankind as a whole.

The risk we run with the extension of the so-called multi-media digitalized society, is in position of one dominating culture. For example, the American culture against which I have nothing but I do not like myself live exactly like an American and I believe you Japanese do not like to live like Americans and the Americans do not like to live like Japanese or Europeans. But nevertheless, altogether and together with the developing countries we have a mix of cultures with different values and it is important to share some basic values that are essential for the progress of mankind and sustainable development of life in our planet. But we must do whatever we can to avoid that information society and the diffusion of information results in a flattening in a loss of cultural diversity, which would be detrimental to mankind.

In other words, cultural diversity is as important in my mind as it is the bio-diversity. We should protect the cultural bio-genoma of mankind. Thank you .

Reikichi Shirane: Thank you. Is that Mr.Uchida,are you satisfied?

Hirohisa Uchida: Yes, thank you for the answers.

Reikichi Shirane: Any other question or comments? Yes, microphone is on the table.

Yoshida: Yoshida of McMillan Research. I have 2 questions to ask. First question is addressed to Professor Hamada about the food.

As Professor Colombo stated, it is often said that by 21st century or immediate 21st century, the world population would reach 10 billion. By that time we will be flooded with problems and energy and food shortages are the problems of paramount importance.

And Mr. Nishizawa advocated hydropower and efficient power transmission as a solution to those problems. As for the food supply, how can we feed 10 billion people? Because nowadays because of the food production tremendous amount of fertilizer, pesticide and so on are poured into the farmland and that results in the degradation of the environment, and at the same time food shortage problem is never resolved.

So how can we feed 10 billion people while living in harmony with environment? What kind of food can we think of to achieve a breakthrough?

And if time allows, probably the other Panelists can answer this question, that is about the environmental pollution. It is the consequence of the mass production and mass consumption and about the slowdown policy. In a nut shell by improving the efficiency of energy, for instance, we should reduce the amount of energy consumed, is that what you mean slowdown policy?

But if such is the system that you are advocating, Professor Hamada, the environmental

issues are so complex that they are especially serious in the developing countries or in the poor population. Because sometimes developing countris and the poor population resort to some means which are detrimental to the global environment.

So in order to feed 10 billion people, we need to give them the employment, the jobs so that they can earn enough so that they can eat. So, while providing jobs to 10 billion people and feed them, how can we implement the slowdown policy? How is it possible? Probably Professor Hamada can answer this qustion.

Takashi Hamada: Thank you for your questions. I think the question No.1 and No. 2 are in fact closely inter-related with each other, so I would like to answer in the mass.

The SDP that propose at present does not contain any decisive factor. In other words, we are still searching for the solution to save the mankind. And by the time the population explodes, what is the level of sustainable development? That would be the question and we can estimate probably where we can balance between the development and the population growth.

In terms of the food supply, just like in the case of water and energy, in fact much of the food is wasted. I don't mean to offend anybody but in the case of Japan, we are stock piling the large quantity of food just to prepare for future. And it is not easy to equally distribute the food but the science and technology made a significant contribution to the transportation technology.

For instance, that is manifested in development of the shipbuilding industry in Japan. Likewise, resources are not distributed in the balance fashion. Therefore, again because of the increase of entropy, we cannot expect the equal or fair re-distribution of the resources. But in order to realize harmony, developed countries should strive to transfer not only technology but also goods and food as well. But of course, these are not beneficial to the environment such as the pesticide. They should not be exported in a large volume but rather we should try to transport the products and technology that would match the local requirement.

Well, it cannot be very decisive absolute solution as slowdown policy, but at least it can postpone the advent of the tragedy for some time. In the evolution, the desire and greed of mankind have developed tremendously but it is the advanced countries, developed countries, they are required to set a good example in limiting their desire so that the developing countries would not repeat the failures that we have committed in the past. And that is where the intellectual property has to be properly shared.

Jun-ichi Nishizawa: I want to be more specific. Suppose that we like eating yellow fin. But instead of yellow fin, suppose that we eat the pray fish that are usually fed to the yellow fin. Or instead of eating beef, if we eat the grains that are fed to the beef then we can feed more people. Or instead of slash and burn type of agriculture, if they transform to the stationary type of the agriculture we think now could be more effective. People are prone to the egoisitic without the malicious intent and researchers sometimes seek for more fund for their activities which are not very tangible to the outsiders.

Reikichi Shirane: Yes, Professor Golombo.

Umberto Colombo: A short comment on that. I believe that first of all, when dealing with the rate of growth of the economy, we should not make confusion between the rate of growth of physical consumption or energy and materials and the rate of growth of economy which as I said earlier, is going to be essentially a growth made out of immaterial goods and services.

So the economy may continue to grow. Employment will shift from being industrial to post-industrial and we don't need in the future to forecast a great increase in the consumption of energy and materials. But in order to prepare for the doubling of population, of course, it is like to see invaded our planet by another planet of the same population as ours. If we are going to be twice the population we have, we must think that we must provide food, shelter, transport, clothing for as many inhabitants in the world in addition to the present population.

So there is no doubt that in order to host a population which is double of the present population, we would have to be much more efficient in energy and materials utilization and as it was just said by my colleagues, we will have to shift paradigm also in the way we are using the food resources.

I believe first of all, we know that if we eat more than 2,000 calories per day, that is not a great thing for mankind. So God has established by nature that you have to reach a certain level of calories per day but if you exceed those calories, now then it will not be good for your health. Now, this is a very important concept, because now we are eating too much and also we are using a lot of calories to produce proteins of animal type and fats which are not so very nice for our organism.

So we will have to really remodel our way of life so as to eat the right amount of calories, the right amount of proteins which can be more vegetal and less animal, less fats, and that will mean by itself the possibility of accommodating a lot more people in the world than at present.

So I believe if we want we should not be afraid of life in a world with twice as many people as we are now. Of course, if we were to double many all the times, there will be a limit beyond which we cannot survive. But I am confident that provided we are wise enough, we can really feed and keep up with the world of twice as many people without dramatic crisis in the economy because of the shift towards less material waste of economic growth.

In other words, economic growth will be largely made of less energy and less material than the type of economic growth we have experienced throughout our lives.

Reikichi Shirane: Thank you very much. Yes?

Koki Horikoshi: Thank you for your valuable comment. My discipline is the biology and it is said that the in face of the crisis the organism tries to come out with the idea, wisdom to survive and this to be the evolution or adaptation.

We may be too optimistic but at least the homosapiens is another species or another living thing in the world. So I am not very pessimistic. About the food, just like in the case of gene re-combination, men are conservative. Especially when it comes to food we cannot be more conservative than others.

And in fact this is inherent in culture or in race. It probably would take enormous

amount of time if we tried to change the eating habit now that various ideas and concepts are gradully changing, eventually we may succeed. That is why I am not very pessimistic and in fact I don't want to be pessimistic.

You may call me a wishful thinking and some are so pessimistic that they dare to say horrible things like because of the arrogance of the mankind, the AIDS epidemic started and so on, so probably human are doomed and so on. But I don't subscribe to that kind of idea. Against, I am not that pessimistic. It seems to me that some people started to develop the resistance against the HAV.

For instance, the infection rate of the HAV among the commercial sex workers in some areas is rather low compared to the other areas. So in face of crisis, the living organism tries to come out with the better idea to survive. Well, this is not a main topic of this symposium so please don't criticize me for what I have just said.
Thank you.

Reikichi Shirane: Thank you very much. Dr. Colombo is from Italy and we expected the Italians eat more than Japanese but I found he doesn't eat as much as we do. And Mrs. Colombo enjoyed having noodles and when she was served a foie gras, she didn't like it. So I can say as a witness that professor Colombo does not consume much food. And I think he is doing what he says.

Yes, any other questions from the floor?

Toshiyiki Furukawa: My name is Furukawa from Osaka National Hospital. I would like to challenge what Dr. Colombo said. We can survive with 2,000 calories and that satisfies the base metabolism. And with 1,000 calorie we can survive to think. But with rgard to transportation or air conditioning, we consume tens of thousands of kilocalories. So I must correct what you have said.

And after that I would like to say NPT, non-prolifertion of nuclear weapons this is the agreement among nuclear countries. And there are some propositions to charge carbon tax. I think that is very strange. People who believe in market mechanism, according to my definition, Malthusian's population theory is applied to the market. People who believe in market mechanism promote the idea of carbon tax. The socialist is now coming up if we charge carbon tax. In order to take advantage of market mechanism, we have to build up a huge mechanism. So I believe the carbon tax is not a successful idea.

So, I would like to invite Professor Nishizawa.

Reikichi Shirane: Dr. Colombo, would you like to respond?

Umberto Colombo: First of all, when I was speaking about calories, I was speaking about calories in the frame of food problem, not in the frame of calories in general for life and as far as energy is concerned, I mentioned earlier that I believe that in the future, we must move from fossil fuels which today represents 90% of the commercial energy which is now used worldwide and 81% if include non-commercial biomass which is used in the third world.

So, we must move from fossil fuels towards different kinds of fuels and I mentioned

renewables and I also mentioned as a possible future option, fusion energy because I am confident that nuclear fusion could be developed in such a way as to avoid the proliferation problems that are typical of nuclear fusion and other problems like danger for big accidents and waste longlife radioactive waste products. So I feel that in the future, we must look towards a system that provides us enough energy but of the good type that is made out of renewable sources or similar to renewable as nuclear fusion.

As far as food is concerned, I have already answered. I believe that there is no limits to food. Water may become a great problem for the next 2 or 3 decades. The problem of securing the world the right quantity of water needed for all its real needs and amenities, is going to be probably the worst problem we are going to be be faced with in the next 2 or 3 decades.

But there are enough ways to cope with these problems provided we know how to put science and technology at work. The real problems I feel are not scientific nor technological. They lay on the political scene on the managerial area. We don't yet know how to orient all these forces towards a world governability and towards a world society that is really sustainable. We don't know yet. That is a main political problem, I am afraid, we cannot I think the scientists can contribute provided they are asked the right questions.

Jun-ichi Nishizawa: Thank you. I think Dr. Colombo has said what I wanted to say. Fortunately, I am a scientist. When we try to reduce the consumption of energy by half or if we get energy by hydyo-power generation, so everything goes into the positive aspect. So I am not pessimistic. So we are in a fortunate situation. We can secure enough energy by science and technology, but you have to consider the inter-relationship, we have to use more wood materials.

But anyway, what is bottleneck for future development? We have to review and consider what are the bottleneck for the future development. So in that sense, system science is a very important challenge for the future. Otherwise, we cannot identify the bottlenecks. So the system science may be the answer.

Reikichi Shirane: Are you satisfied? Do you have any further questions? Yes, Mr. Kawasaki?

Masahiro Kawasaki: Thank you very much. I think all the Panelists have talked but there is something which I do not understand. You said paradigm shift is necessary. But what is the direction towards the paradigm shift? I think there should be several options for our paradigm shifts.

Especially, what Dr. Colombo has said and what Dr. Horikoshi said that he need to preserve bio-diversity, that is symbiosis of the various kinds of diverse things. Is that the objective of paradigm shift?

Mr. Furukawa said that most of the systems is based on the market mechanism and we have achieved a lot of results by science and technology, but diffusion of science and technology is very difficult because there is a bottleneck in the distribution. So for everbody to enjoy the result of the science and technology and if that is the objective of paradigm shift, system approach may be necessary. But where do we start in paradigm shift? Which is the area we should start with?

Umberto Colombo: I think the purpose of paradigm shift is to secure sustainable development, that is a develoment, a type of development that satisfies the needs of the present generation without jeopardizing, without damaging the future generations to satisfy their own needs. That is the definition given by the Bruntland Commission that wrote the famous report in 1987.

Now, given this paradigm, then we must work and the problem is that the market economy, the market mechanism which is by far superior to the communist or the centrally planned economy as shown by defeat of the Soviet Empire.

Well, the market economy is not without its own defects. The market economy tends to priviledge, the short term. If you look at any ecoomic journals such as Business Week or Fortune or Wall Street Journal, you will immediately notice that companies are judged according to the results of the last 3 months, not even of the last year, and the forecast for the next 3 months. The market is very clever in being an immediate instrument of evaluation. But the market is not clever enough to forecast future needs, future problems. The market is a short term, short range instrument. And this is the dilemma of our society.

We have defeated communism, because communism which promised to give happiness to the world and also promised to take care of the future by the 5-year plan, did demonstrate that not only was not able to plan for the future but it was not even been able to manage the present. And we are left with the market which is an imperfect weapon I am afraid.

And so the problem we have in our world is how to correct the mechanisms of the market, how to superimpose to useful instrument. Something which allow us to think more long range into the long-range future and wider thinking of the whole planet. Because if we think of ourselves and forget what happens in the other countries, we will be confronted with big migrations, we'll be confronted with phenomena and unrest that expanding through television and becoming present to our eyes in real time will determine a great deal of dismay throughout the world.

Jun-ichi Nishizawa: Yes, you have to identify the bottleneck as soon as possible. I think that is the first thing to do. So you have to identify the bottleneck first. Sorry, I should not have referred to Japan but CFC, that we have spray with CFC, what should we do? We have readers contributing to the newspapers, so many bureaucrats at the MITI say why don't you use it because we do not have any rules.

So this reader who happens to live in Sendai and I respect him very much, he tried CFC from automobiles and he asked the manufacturer to collect them. But the manufacturer said no, and he just collected CFC. But recently, manufacturers started the collection of CFC. Our ministry said there is no regulation, you can use it but that can happen quite often. There are many reasons for such unreasonable behavior. But sometimes you should do this but you do not do it because there is regulation.

Because there is a sort of vested interest in the people so people just try to avoid to deprive of vested interest from the people but if corporations have a long term view and try to collect CFC then they will lose their competitiveness with other companies, but it is very hard to be an initiator. But the first step you should take is to identify the bottlenecks, and ministries should realize what are the important bottlenecks and the scientists or engineers should

identify those bottlenecks and show the basis for that, endorsing factors.

Reikichi Shirane: Time is rather limited. Anybody elso who would like to ask questions, that will be the last question. Would you please identify to whom you are asking your question.

Osamu Yamamoto: Maybe this is to Dr. Colombo or Dr. Mandelbrot. Maybe to Dr. Mandelbrot, please. President Nishizawa or Professor Hamada have repeatedly said that there is a limit to human desires and ambitions and that people continue to use material. And that Mr. Hamada said controlling the physical or psychological aspects, he said something about that. For us Japanese it is easy to understand and it sounds all right. But what about the people in Europe? How would they accept this school of thoughts?

Reikichi Shirane: Professor Mndelbrot, perhaps you would like to comment?

Benoit Mandelbrot: Well, I am sorry I didn't quite understand your question. Between Japanese and Europeans I was raised in the environment in which waste was just as despicable, incomprehensible as description made for Japan. Waste was not something which was brought to my culture at all.

My wife never throws away anything. Because that will be waste. In other words, the differences between Europe and Japan on this account, I think, is influenced by the contrast between conspicuous consumption of Americans after World War ll, and the poverty of other countries, it was a very passing situation.

I think there is much less waste now in the United States also. Almost visibly one sees less waste as time goes on. Therefore, the cultural differences should be always remembered and I hope certainly agree about the importance of not forgetting that people are different and I also believe that preserving variety of culture is very important.

But on certain basic features, the differences are smaller than it may seem. I remember somebody telling me, well, Frenchmen are very wasteful, we, the careful German housewives never throw things away. Well, French housewives don't throw away that easily. So, in his sense the differences were not so great. It is perhaps a matter of one passing generation which waste was favored by public policy or pricing of taxes on paper or taxes on boxes or publicity for having boxes in boxes and boxes. But this is a very, very recent and therefore probably shallow development.

I think that this matter of sustainability is a mass problem but not quite difficult as it would appear by comparison with the most conspicuously wasteful Americans of one particular conspicuous period.

Jun-ichi Nishizawa: I think this cannot be forced upon. One needs to get people to understand. The Catholic lives I think also see this. It's a matter of spirituality. Maybe the representation was not well presented but I think to a certain extent both East and West do understand and share the common understanding.

Reikichi Shirane: Thank you very much. I think we would like to continue this discussion, but

time is coming to close.

I think we could continue like this and it is my duty that I am supposed to summarize the discussion that took place here. But I think it is going to be a very difficult task for us.

I think that the topic in 1920s and 1930s, the new generation of those days also considered paradigm shift and in fact the paradigm shift is indeed an important issue for our generation. As Professor Mandelbrot said, eyes are important pictures when it comes to literacy what paradigm shift would take place. Literacy is an important issue. I am sure that there will be a major paradigm shift when visual comes into literature.

So there is also paradigm shift which we see with the generation shift and there are also countries which have been so-called developing countries will also have to consider a paradigm shift together with the developed countries. This again is also an important aspect of the paradigm shift.

Multimedia is very much talked about today. If you take this in the context of developed countries, I think we may make a serious mistake. But if we also take into considertion developing countries' literacy, their ability to read and write, a leaprogging could be achieved by introducing letters and pictures or other audio visual methods or if you use a multimedia in the education, we can leapfrog and do it in a much shorter period of time rather than what it would take in a hundred years.

So it would be commonly accepted what has been accepted as unknown will change and we may realize that paradigm shift has in fact taken place.

We have discussed about the Paradigm Shift in the 21st Century from the perspective of the distinguished figures from the different discipline. For me it was a very easy task because we had distinguished Panelists.

This will conclude the Panel Discussion session.

Thank you very much.

発行者　宮原弘光
発行所　財団法人　本田財団
〒104　東京都中央区八重洲2－6－20
TEL.　東京 03（3274）5125